Table of Contents

Utah State of the State
Drought Assessment and Mitigation Report

Abstract

Utah is an arid place. Drought it is a climatic factor that, depending on its duration, can cause extreme economic, social, and environmental impacts, but it is not the norm in Utah. Drought is generally impossible to predict and hard to detect until the signs of its presence are impossible to miss. Utah has been gripped by a drought, for at least five years, that by some standards is potentially even more devastating than the drought of the fifties or even the "dust bowl." All parts of the state have been hit, including the public lands that make up a significant part of the state. All uses that occur on public land have been impacted by this drought cycle. Impacts include severe plant mortality on some sites, record low flows in rivers, streams, and springs, and mortality and poor reproduction in some big game species. There is an increased fire danger and potential for catastrophic fires that could threaten homes and habitat, and the possibility for increased invasion by opportunistic weedy species, annual grasses, and insects. Because environmental impacts have crossed all jurisdictional and ownership boundaries there are significant collateral impacts from actions on any of these lands on surrounding lands, direct impacts to rural economies, and increases in social issues like out-migration from failed farms into urban areas.

But the impacts of future drought can be at least partially mitigated by cooperative partnerships between public land management agencies, state agencies, tribes, public land users, and the Governors office. This can be accomplished by forming multi-agency and multi-disciplinary teams to identify and implement early detection and early intervention strategies. These instruments use Land Use Plans as a base to launch mitigations early in a drought cycle and lay out a systematic approach for insuring that the critical recovery phase is factored into land use decisions. In addition they can identify "survival tools and education" opportunities that help private landowners and public land users plan for changes in use during drought cycles.

Drought is a normal but unpredictable part of the climate in Utah. Drought impacts have been exacerbated by changes in populations, demographics, and shifts in public land use paradigms. But these changes have also opened the window of opportunity for the development and deployment of new tools that will help multi-agency; multi-disciplinary mitigation teams detect drought earlier and start the mitigation process early in the cycle.

The purpose of this report is to compile a multi-agency overview of drought related impacts and issues primarily on public lands in Utah. It is not all-inclusive and only represents a snapshot in time of fall 2002. The State of the State Report is the cornerstone for future multi-agency cooperation, coordination, and statewide planning for the early detection, early intervention, and the mitigation of drought related impacts.

Key Words: Drought, Climate, Social Impacts, Economic Impacts, Environmental Impacts, Cooperative Partnerships, Multi-agency. Multi-disciplinary Teams, Mitigation, Monitoring, Planning for Drought, Land Use Planning, Early Detection Strategy, Early Intervention Strategy, Recovery, Science, Science of Recovery.

The First Drought of the New Millennium

One of the driest Januarys (2003) on record has ushered in the fifth year of an extended drought in Utah that has not only had impacts across the state but one that has also been pervasive across the west. This dry cycle has straddled the transition from the twentieth to the twenty-first century. This is the first drought of the new millennium. Several drought cycles were recorded in the previous century, the most notable being the drought in the fifties that, in Utah, was probably more devastating than the Dust Bowl in the thirties. Scientific and anecdotal evidence suggests that these cycles were responsible for significant environmental, economic, and even social impacts.

Each community in Utah has its own set of stories and histories about these impacts. Without a doubt these cycles caused farms and businesses to fail. There was some out-migration from hard hit rural communities into the urban areas along the Wasatch front. There are stories of severe environmental impacts as well: excessive erosion, historically dependable water sources failed, grass became dormant or suffered high mortality, and the condition of public, private, and state resources declined dramatically.

The first drought of the new millennium has had the same environmental impacts, but by some reports the social and economic impacts have been exacerbated by a dramatic increase in population (since the fifties), changes in demographics, and changes in uses and user paradigms on public lands.

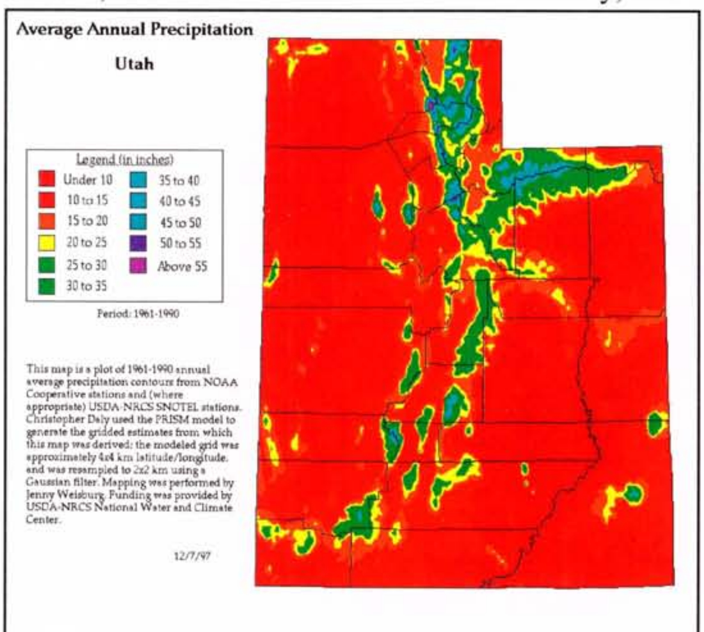
The Governor appointed a drought task force early in 2002 primarily to look at the impacts of drought on critical water storage and uses. State and federal agencies likewise appointed a drought task force in 2002 to look at economic, social, and environmental impacts on state, private, and federal land statewide. Both measure impacts and identify mitigation strategies. Both use this drought to plan for better survival during the next cycle.

Utah is an Arid Place

Drought is not the normal climatic condition in Utah but it is a normally reoccurring part of the climatic cycle. Two of the four true deserts found in the United States--the Great Basin desert which covers almost half of the state and the Mojave which extends into Utah around St George—are located on the west side of the Wasatch Divide. Almost the entire eastern half of the State, except the High Uintas, is within the colorful Colorado Plateau bio-geographic region. While this vast area has desert sites within its boundary, it is not a true desert, but it is arid.

While not all of the state is desert, all of Utah is arid, very arid. Annual precipitation varies across the state from Alta where 400" of snow (56.19" precipitation) is not uncommon and in the southeast at Hite Marina where snow seldom falls (5.31" precipitation). The average across the state is 11.83 inches per year.[i] In comparison to the Northwest this precipitation total is meager—for example it is less than one third of the total precipitation in Washington State. Utah is not the driest state in the country but it is ranked second behind Nevada that receives 9.46 inches per year.

With some planning and a history of diligence and creativity, the citizens of Utah have adapted to living in an arid environment. The state successfully maintains a large agricultural industry, growing urban centers, a vast and diverse recreational industry, and a high quality of life.



Utah's population continues to grow rapidly. Much of this growth has occurred since the last major drought in the 50's. In recent decades newer uses of water have been introduced such as considerations for populations of endangered species, the expectations of water sport recreationalist, changes in rural/urban demographics, in-migration of new families, and subsequent urban growth.

Utah agricultural water use has slightly declined over the last twenty years, but public supply and total water use in Utah has increased.[ii] The source for most of this water is found in the uplands managed by the State, the Bureau of Land Management, and the U.S. Forest Service. This water, in the form of winter snow and rain storms fills reservoirs—the storage source of precious culinary and agricultural water—and provides millions of recreation hours per year for boaters, rafters, and fishermen.

But public lands provide more than water for creeks and reservoirs. Utah public lands also provide timber, woodland products, habitat for wildlife, wild horses and burros, forage for livestock, thousands of miles of foot and OHV trails, oil and gas, and minerals, millions of acres of wilderness and proposed wilderness, and some of the most vast and colorful landscapes in the world. Most of these lands receive less than 15 inches of annual precipitation and all of them regardless of altitude are susceptible to drought: seasonal, site specific, widespread, or like this cycle, pervasive across the State.

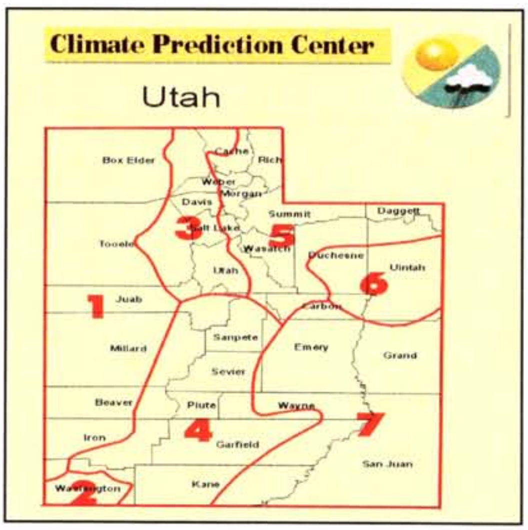
Drought is not the norm in Utah nor is it a stranger to our arid climate. It sneaks up on us and causes serious social, economic, and environmental impacts. But with teamwork and prior planning we can mitigate most of the issues related to drought.

History of Drought Cycles in Utah

Drought cycles come and go in Utah. Some cycles last one season, (i.e.. a monsoon season with low precipitation) some, like the current one, last for several years. Drought is situational, can be seasonal or site specific, and affects different parts of the society, environment, and economy differently depending on its duration and location.

While climatologists may disagree about the duration of this drought cycle and about when it might end, most agree that Utah has not experienced a drought as intense since the drought in the fifties. Our state was impacted by the "Dust Bowl" drought in the thirties but did not experience it as pervasively as the mid-west where giant dust storms rode high, hot winds across the Great Plains, forcing thousands of people to relocate. Many of our senior citizens not only have memories of caravans of destitute farmers crossing the state, but also share vivid personal stories

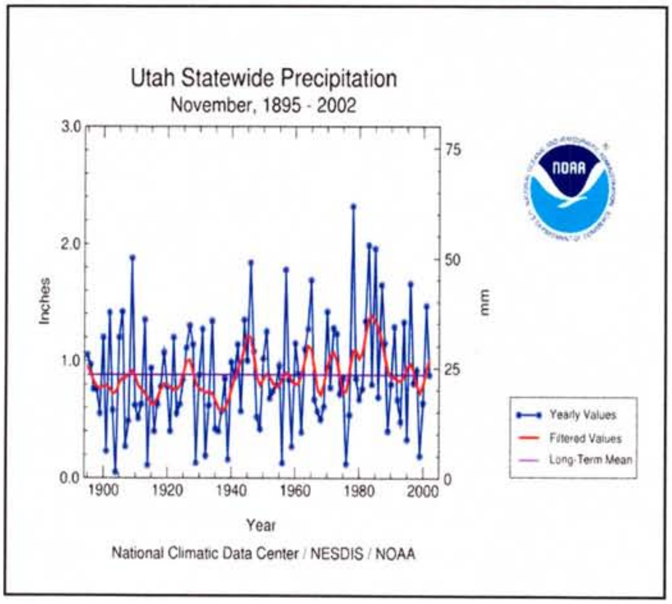
A considerable quantity of weather data is available for the state such as precipitation records from as early as 1895. State climatologists collect data in the seven climatic Divisions identified in the Palmer Drought Severity Index. (Figure at left) Those data (Appendix B) suggest that the only predictable part of the climate cycle is that drought is generally site and season specific. For example in 1950 a drought started in all of Utah except Division 3. While precipitation in the rest of the state was well below normal for a couple of years, in Division 3 it was slightly above normal until about mid-summer of 1952. The drought broke in the winter of 1951/52 but the record shows that the state and particularly Division 3 probably did not get normal late summer showers. Drought came back to Utah in 1953. In Division 1 the drought lasted until mid-summer of 1956 but the drought was generally pervasive across the state, until 1962, with some Divisions reporting short periods of above normal moisture scattered throughout the drought cycle. (Appendix B)



There are very few climotologists who will risk vocalizing that they can predict the frequency or intensity of drought cycles, or for that matter, any climatic pattern. While some climatogists claim progress has been made in computer-assisted predictions, most choose to limit their prognostications to the immediate short term.

In Utah, there is considerable debate about the frequency of drought. David Grider, USFS[iii], reported in a presentation that eastern Utah experiences drought about 71% of the time and western Utah about 51%. Mark Eubank[iv], in an interview about drought said: "Utah actually experiences a little more above normal precipitation than drought: about 2.1 wet years per 10 years and 1.7 below normal years per 10 years."

Regardless of the debate about frequency, predictability, or duration, drought is a frequent visitor to Utah. (Utah Statewide Precipitation graph below) Sometimes it stays for one season, sometimes it hits only one season for several years in a row, and sometimes, like this cycle, drought stays and impacts the entire state for several years. Each drought cycle brings with it impacts that can be measured immediately and others that are felt for years.



Each drought cycle in Utah's history has impacted a portion of the economy, had short and long-term environmental impacts, and has had impacts on our social relationships. These are predictable and within certain parameters can be mitigated to lessen impacts from future drought cycles.

The return to "normal" precipitation is a communal sigh of relief. Storage levels in reservoirs, especially those that provide water to urban areas, visibly fill during the spring snow-melt and winter snows and spring rains bring a flush of green to a landscape that may have looked burned and absent of plant life. It is easy to rush judgment, to assume that one good winter has eased or even eliminated the impacts from the past drought. Drought is not only insidious in its inception but also in the manner that some impacts are hidden. For example, some soils, heavily depleted during an extended drought, may not have recovered even a small part of normal soil moisture for any number of reasons such as: soil crusting, elimination of ground litter, and a reduction in above surface vegetative biomass that all impact percolation of precipitation. This impacts plant recovery (vigor and biomass) and in the long-term impacts replenishment of aquifers. Impacts spread from this simple source until humans realize, through economic measurements, that the drought continues to impact society and the environment.

Studies[v] indicate that many plants that have survived the drought recover fairly rapidly. The studies also show that if recovery is measured in total biomass that some sites may take longer to recover. The recovery period is not the same for all species of plants or soil types. Generally, the longer the drought the longer the recovery period, primarily because of a reduction in total biomass, reduction in surface litter, and poor seedling establishment.[vi] Recovery from a drought cycle in Utah will take patience, partnerships, and pre-planning.

A Multi-disciplinary, Multi-agency Team Approach
For Drought Assessment and Mitigation

By mid-summer, 2002, most of Utah had been experiencing moderate to severe drought for up to four years. Reports were coming into the Utah BLM State Office about the deteriorating condition of vegetation and the increased deficit in soil moisture on public lands. Questions were being asked not only about how to manage the current situation but also if the State Office had guidance concerning drought management. A quick inventory showed that the Bureau had a significant amount of information for the management of various resources including vegetation in the form of Standard and Guides and in the Code of Federal Regulations. But the agency had little information about early detection, early intervention, or planning for drought in any form including existing Washington Office Guidance, Technical Manuals and Land Use Plans, the document on which the agency makes area specific land use decisions. This absence in itself did not threaten the integrity of these LUP's as changing land uses for a variety of programs were inherent in the plans.

A meeting of the Resources Division of the State Office was held to brainstorm drought related issues, mitigations, and possible Best Management Practices. After a follow-up meeting it became clear that the Bureau needed to address drought and other climatic variances at least in Utah. State Office staff quickly canvassed their counter-parts in the Field Offices requesting information, photos, and opinions about drought management.

A trend began to assert itself:

1. Early detection and early intervention techniques and/or processes, if they existed, were not applied across jurisdictional boundaries.
2. The extent of this drought cycle and the social, economic, and environmental impacts were generally being mitigated, if at all, within each agency's jurisdictional boundaries.
3. While there is a fair amount of science concerning drought management and mitigation, much of it was not readily available to either agency personnel or public land users.

The Utah State Office team recognized the need to identify a list of drought indicators and to implement a process for early detection of drought in a timely manner. The agency needed to create and implement a process of early intervention to mitigate social, economic, and environmental impacts of drought and we needed to incorporate early detection and early intervention into our Land Use Plans. It became even clearer that BLM should not attempt to manage drought in a vacuum; we needed to have partners because any decisions BLM made to manage drought impacted other public and state lands, and private landowners. The BLM team recognized that the process should be multi-agency, multi-disciplinary, and public.

Utah Partners for Conservation and Development

Members:

USDI Bureau of Reclamation
USDA Farm Service Agency
Utah RC&D Councils
Utah Association of Conservation Districts
Utah Department of Natural Resources
USDA Natural Resource Conservation Service
Utah Department of Environmental Quality
Utah State University Extension
Utah Department of Agriculture
USDA Forest Service
USDI Bureau of Land Management

Part of the intra-office exercise was to identify existing partnerships that BLM could work with to accomplish these goals. Because BLM was a member of the Utah Partners for Conservation and Development it was decided to present a proposal to the Partnership Action Team, the heavy lifting arm of the Utah Partners group. By the end of July a team had been formed and a date set for a tour of the state to do:

- a rapid assessment of impacts from the current drought cycle on both private and public land; assess impacts to all public land programs i.e.: grazing, oil/gas, wildlife, recreation, etc.;
- provide short and long-term recommendations to land managers and public land users;
- prepare a State of the State report;
- develop strategies for incorporation of early detection, early intervention, and public participation processes into LUPs.

The Drought Assessment and Mitigation Team (DA&MT), understanding that there were several definitions of drought, agreed, at least in the short term, to a definition that came from the Bureau of Land Management Utah State Office as illustrated.

DA&MT Working Definition of Drought

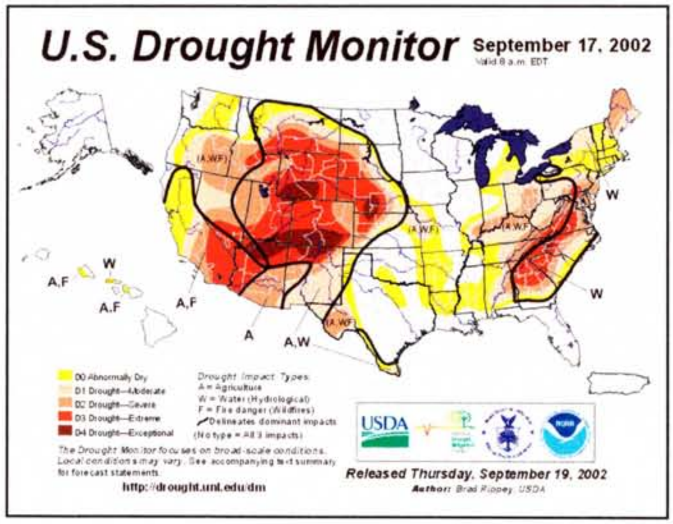
Drought is a negative deviation from normally arid public land conditions that results in:

- Significant volume decreases in surface and sub-surface water sources
- Moderate to severe economic and social impacts
- Potential conflict between competitive uses
- Short and long-term environmental impacts and damage to public and private land resources

This definition is fluid but it seems to fit all four kinds of drought and the conditions and impacts from this drought cycle. The DA&MT suggests that rather than debating the various definitions of drought that government agencies and partners focus on identifying drought indicators, drought assessment and mitigation strategies, and drought planning to mitigate various impacts that result from the four types of drought.

Assessment of the Current Condition

In mid-September, 2002 a team comprised of: Randy Parker-Utah Department of Agriculture, David Grider—U.S. Forest Service, Dr. Roger Banner—Utah State University Extension, Larry Ellicott and Lisa Coverdale—Natural Resource Conservation Service, and Larry Lichthardt and A.J. Martinez—BLM, toured most of the state. Sites visited: BLM administered Lands:



Moab, Montecello, Hanksville, GSENM, Cedar City, Richfield, and Fillmore Field Office areas.
USFS: Uinta (drive through), Manti La Sal, Dixie, and Fishlake National Forests
NPS: Glen Canyon National Recreation Area, Capitol Reef NP (drive through)
State Parks: Green River, Otter Creek, and Yuba Reservoir. Drought conditions across the state and the west, for that trip, are shown in the U.S. Drought Monitor September 17, 2002 figure above.

The Multi-agency tour of Southern Utah provided participants the opportunity to see conditions and drought impacts first hand and visit with land managers, Extension agents, and members of the public. The tour provided visits to representative geographic areas to get a sense of the broader impacts. In addition, the team met with community leaders and elected officials for reports on broader economic impacts. It is important to note that the team was not conducting scientific observations nor gathering scientific data to make specific recommendations. Even though the team visited specific sites and the team was comprised of subject specific experts, the following observations are general in nature.

Environmental Impacts—Vegetation:

Utah has been in a prolonged drought with Southern Utah particularly hard hit in 2001-02. Limited moisture in both the winter and summer months meant broad adverse impacts on plant growth across the region. In many of the areas visited, vegetation (several species) exhibited severe stress. Many of the grasses had not received enough moisture to break dormancy. Plant mortality was observed in many of the areas the team visited. The lack of moisture and prolonged dormancy has also meant there is limited seed production to generate new plants.

There has been little forage re-growth after the previous year's grazing season. The rain that had been received two weeks prior to the team visit was the first moisture of the entire season in many areas. Some crested wheatgrass and other species broke dormancy and produced 2-3 inches of growth and then returned to dormancy. Moisture, that provided for late season green-up, created optimism among livestock producers however, it created additional concerns for resource managers who understand the rancher's need for forage but are also responsible for maintaining or improving range health. Other vegetative impacts included severe mortality in stands of Big Sage, Rabbit Brush, and Bitter Brush, which, in these areas will critically impact wintering deer.

Across the four-corners states there continues to be a significant infestation of Pinyon Pine by the pine beetle Ips confusus. When the trees have normal moisture reserves they can usually successfully cast out swarming beetles, however, after a few years of declining precipitation and increased competition for less moisture, the trees become weakened and cannot protect themselves from invasion. Some stands on Cedar Mesa and around Boulder, Utah have as much as 40-60% mortality (estimates only). Clearly in the first years after die-off and before needles have been shed these stands are prime fuel for wildfire. Before or after a wildfire there is an increased risk of invasion by Juniper and exotic plant species, however, if not invaded, these stands have the potential of recovering (native species) through natural succession.

Environmental Impacts—Water Resources: Many reservoirs in the state were at the lowest levels they had been, many since they were built. For example at least three feet of the intake ring in Yuba reservoir was showing, indicating that the remaining conservation pool was dangerously low. Lake Powell had an extreme drop in elevation (storage) of almost 90 feet from normal pool levels. In the period between April and July, inflow was about 14% of average.

Many of the State's rivers and streams were running at 10% of normal. In some extreme cases, anecdotal reports from southern Utah suggested that some streams were below 1%. While the team has not gathered data on mortality in these depleted streams and lakes, there certainly has been some impact to riparian habitat and dependant species and fisheries. Limited water resources have put added pressure on some riparian areas from livestock and wildlife. Animals have tended to congregate where water was available. Where water was made available in a more dispersed area through hauling and development, there was less damage and broader use of forage.

Environmental Impacts—Wildlife

Wildlife populations have been hard hit by the drought. Buffalo and elk herds, in southern Utah, seem not to be as hard hit as other species, although both species were targets of concern in regards to competition with livestock and depredation on private lands. However, in the northeastern region of Utah, DWR reported that elk were in direct competition with deer for browse species normally not utilized by elk. It appeared that the hardest hit big game species in the region were antelope and mule deer. Many of the deer herds the team observed had less than two fawns per ten females. Many females were in poor condition, which will probably impact conception percentages. Some fawns carried spots in mid-September, which indicated late births (a carry-over drought impact from the previous year) and probable high mortality. Fawns were almost non-existent in antelope herds. Note: These are very limited observations and do not represent actual percentages which may vary or not be as pessimistic. All of the team members expressed concern about the coming winter and wildlife populations. They predicted severe wildlife losses, even if the winter is light, and increased competition for scarse vegetation. With a heavy winter, the wildlife losses are projected to be much more severe. (Appendix G)

Environmental Impacts—Wild Horses:

The team did not observe wild horses but resource managers reported that wild horses populations in the region had suffered some mortality even though the BLM conducted emergency gathers (about 1400 animals removed [vii]) to reduce impacts both to remaining animals and water and vegetative resources. Wild horses are highly competitive with other livestock and wildlife, often driving other species away from available water. Few foals were born in 2002. (Ibid) Going into the winter the animals are in poor condition that could result in additional mortality.

Environmental Impacts—Fire

Summer wild fires, in 2002, were fueled by some of the driest conditions on record. The most ominous fires were in the four-corner states. With relative humidity and fuel moisture in single digits and high, hot winds, fire behavior was at the least extreme. The fire in the Book Cliffs in the summer of 2002 was one of the largest in recent Utah history. Extreme weather, steep and dangerous terrain and remoteness hampered fire-fighting efforts. But probably the single largest influence were the extremely low fuel and soil moistures caused by this extended drought cycle.

Environmental Impacts—Soils

Soil moisture is as low as it can possibly be in many sites across Utah. As a result it is highly susebtiible to disturbances of all types inlcuding impacts from hooved animals, cross-country travel by Off Highway Vehicles (OHV), and irnonically, from high intensity rains. For example, in the Circle Cliffs area of the Grand Staircase Escalante National Monument, intense fall rains caused extreme head-cutting and sheet erosion because the soil moistures were so low that soils on that site could not resist movement. The unusually high winds of the spring of 2002 removed an unknown amount of soil all across the southwest in blinding dust storms.

Economic Impacts—Grazing:

Livestock producers have been faced with liquidating herds or trucking livestock to out-of-state pastures due to one of the region's worst droughts in memory[viii]. Cattle producers have been hit by a combination of drought and low prices. The severity of the drought has lead to a liquidation of cattle across much of the Western United States. The volume has forced cattle prices lower. The drought and associated lack of forage and water has dictated the need to reduce numbers, however, the lower market prices--as much as 40 percent less (Ibid) for cows and calves--has made it a more difficult decision. Exacerbating the situation is the limited hay production and high prices in the region. The lack of grazing resources, low cattle prices and high priced hay, producers are in an increasingly problematic situation.

There are a couple of concerns associated with the current liquidation of cattle. First, the genetics that have been developed have been developed to address geography and environment while allowing for an economical cattle grazing operation. Utilizing the private/public land mix has been a paramount consideration in developing genetics that can survive and in average conditions, even thrive. Conditions this year have required reductions through slaughter or relocation that will adversely affect livestock numbers and ranches in the region for the foreseeable future.

Public lands – BLM, Forest, Parks, Monuments, State Parks, etc,-- dominate Southern Utah's landscape. Many rural communities and some livestock producers are heavily dependent upon multiple-use of the public lands. Livestock grazing is an economic contributor to rural areas and the statewide economy. Liquidation of livestock and ranching operations will be felt in these communities. The following is an opinion by Randy Parker, Utah Department of Agriculture economist, based on his research and observations from the DA&MT tour.

> From a micro point of view, it is important to recognize the impact of displacing or liquidating even a single livestock (cattle) operation. If an average sized cow-calf operation with 500 mother cows goes out of business due to the drought, there is a direct loss to the local economy of over \$200,000 in farm gate sales. This is based on a ninety percent calf crop and 500 pound feeder calves marketed at \$.95/pound. The multiplier effect of an average cattle operation is 3-4, especially in an agriculture dependant area, providing an annual economic loss of around \$750,000. The 2002 Utah Agricultural Statistics reports 71,000 cattle in southern and southeastern Utah, thus a forty percent reduction (28,400) in cattle inventory in the region based on the above presented scenario, would create a loss of economic activity of over \$42 million. Similarly, the loss of an average sheep operation of 3,000 ewes would mean a \$300,000 loss in one-time

farm gate sales. This is based on an assumption of 100 percent lamb crop on 125 pound market lambs sold at $.80/pound. Using the same 3-4 economic multiplier, there would be an estimated annual loss to the rural Utah economy approaching $1 million. The 2002 Utah Agricultural Statistics reports 78,000 sheep in southern and southeastern Utah. Therefore a forty- percent reduction (31,200) in sheep inventory in the region based on the above-presented scenario would create a loss of economic activity approaching $10 million.

Based on livestock numbers being sold at auction or transported out of state in search of forage, higher numbers of open cows, and projected reductions being anticipated by the land management agencies in some allotments, an estimate of forty percent reduction in livestock numbers could be considered conservative with an economic loss to the economy approaching $50 million.[ix]

Economic Impacts—Tourism:

The state's southern region has in recent years become more dependent upon tourism. Visitor numbers are down. The lack of water in the rivers and the threat of large fires seem to have reduced visitor numbers and economic activity. It has been reported backpacker groups and commercial recreation businesses have cancelled visits due to heat and lack of water. For example, the annual Friendship Cruise, on the Green River, was cancelled, for only the second time in its history. Low water levels in late July and August contributed to a loss in visitors in Huntington, Deer Creek, and Gunlock State Parks, because they were unable to launch boats. Utah State Parks reports an 8.3% decline in visitation to State run reservoirs.[x] Some like Otter Creek directly impact the economy of Antimony and that area of southern Utah. The manager of the Green River State Park reported to the DA&MT that he had not observed either private or commercial boats floating the river since July 2002. Therefore, rural, travel/tourism-dependant economies, adjacent to these parks, are acutely impacted.

Environmental, Economic, and Social Conflicts

The team identified several existing conflicts. All have a base in environmental impacts, which translate into economic impacts, and if they go unresolved they synthesize as social issues.

- Drought exacerbates the impacts of wildfire but the **exclusion of fire** from fire dependant ecological sites exacerbates the impacts of long-term drought cycles. For almost one hundred years the management of natural resources has included immediate suppression of all wildfires on public lands. As a consequence these sites have built-up higher fuel loads and are now at a high risk for catostrophic fire and invasions by insects such as pine beetles.
- **Heavy competition for depleted resources** between livestock, wild horses & burros, and wildlife, specifically elk on both private and public lands. There seem to be conflicting agendas between the agencies for the allocation of resources for these species. Livestock numbers can be reduced immediately if necessary. Wild horses and burros can be removed within a relatively short period of time given an increased capability of holding facilities to accommodate these extra animals and of course budget. Big game species are problematic in that the Utah Department of Wildlife Resources utilizes natural mortality and adjusted hunting permit numbers to thin herds. In addition this segment of resource management has a

well organized and powerful lobby that resists changes in herd numbers across the state.

- **Stand conversions** e.g. cool season to warm season species and invasion by weeds and exotic plants or conversion of dominant over story in P/J sites from Pinyon to Juniper or an invasion of weeds and exotic plants. Drought impacts sites are highly suseptible to invasion by opportunistic insects and annual grasses and weeds.
- **Communication gaps** between jurisdiction managers, and with users. Several contacts noted that the land management agencies were not coordinating and communicating, about drought, with each other or with public land users.
- **Rushing past Recovery**—There is an understandable impulse to want to utilize resources before they have recovered sufficiently. Vegetation and soils will need more than one "normal" precipitation cycle to recover.

Strategies for Management—Short term

Strategies for management—seamless management:

The land management agencies, in cooperation with other member partners of the Utah Partners for Conservation and Development, should develop and implement a strategy for seamless management. This does not imply that each agency must abdicate their organic legislation, rules, regulations, and procedures in the name of consensus and cooperation.

"You guys need to talk to us and to each other at the same time." Del LeFevre, Garfield County Commissioner and rancher told the DA&MT during the tour.

He went on to tell the team that often he felt it was up to him to mitigate any differences in yearly scheduling between the Forest Service and BLM. Instead, he suggested that it might make more sense to have both agencies call him in at the same time to discuss the grazing year. This would include other permittees that shared his allotments managed by both agencies.[xi] Seamless management, as defined by the team, is nothing more than cooperative communication between all agencies before a decision is made. This allows the agencies and the permittee an opportunity to suggest or explore a number of options or at the least prepare the permittee for temporary use reductions. In addition the permittee can look at options for herd and ranch management before his finances reach critical mass.

Seamless management is simply looking for common ground in assessment guidelines, assessment tools, and options for management of public lands. Examples include: the development and management of public and private resource reserves, seamless databases, and seamless Land Use Planning (this does not imply one inter-agency LUP but rather complimentary and mutually supportive planning that should include other plans in the same geography such as other federal agencies, State, and County plans).

Strategies for management—Assessment Guidelines

Drought is normally site or area specific; however, the current drought cycle in Utah has been pervasive over much of the State for at least 4 years. [NOTE: the term "site" has several uses. For purposes of this document it refers to areas within an allotment.] Some areas of the State, during this protracted drought, have seen improved precipitation conditions, such as in 2002 in northwestern Box Elder County and spring 2001 in the Kanab and St. George areas. But in general, drought conditions in the State have been widespread and resulted in reduced plant vigor, root pruning, mortality, and possible long-term changes in plant composition. Current drought conditions have affected both soils and surface water. Soil erosion has increased, as would normally occur with severe drought conditions, and surface water quantity and quality have declined.

While there is a "mild El Nino" event forecast for this winter (2002/2003) it is doubtful that it will offer more than temporary relief. The impacts of the drought will be longer term and will take time and several years of average or above average precipitation to mitigate the impacts of. At least one more below normal precipitation year (2003) is predicted as well as the continuation of a long-term drying trend.

It is important to recognize that drought conditions need to be assessed on a site specific and proposed use basis. Even as statewide as this drought is, conditions vary across the State and within Field and Ranger District Offices. The ability of the rangelands to sustain themselves and provide livestock forage or to support other uses is affected by the type of vegetation, proposed season-of-use, the growing season dates, timing of precipitation events, vegetation conditions, and the kind of livestock being proposed for use. An analysis of these factors will determine what level of use, if any, is appropriate for a specific site.

The following are recommended "common-ground" range land specific assessment guidelines that public land managers and intra and inter-agency teams can use to assess range readiness under any climatic condition including drought. Furthermore they can be shared with public land users so that they are looking at range resources from the "same page."

Site Specific Assessment Guidelines—Short Term

The most important and immediate step is to visit with public land users as soon as possible to discuss the drought, possible ramifications, and potential future actions. All permitted public land users should be contacted before a formal letter outlining proposed actions is sent. Permittees that graze USFS and BLM allotments probably are the most immediate and highest priority.

The following items (assessment questions) should be considered when determining if livestock grazing should be permitted in the short term. **These assessment criteria should not be viewed as a checklist but rather as a general guide to facilitate the team process.** Other tools or additional information, including Utah BLM Standards and Guides, can be found in Appendix E. **It is highly recommended that a multi-agency, multi-disciplinary team approach be used when making an assessment for any program, activity, or use.**

Assessment criteria for evaluating condition

1. Will the proposed use provide for the recovery of plant vigor? (Grazing Management Guidelines, Tech Notes, Range 34, Appendix E)
    - Analysis of these factors will help determine needs for relief
        - Type of vegetation
        - Season of use
        - Growing season dates
        - Timing of precipitation (normal year)
        - Range condition (residual growth, litter)
        - Class of livestock
2. Is root development adequate to maintain plant growth with the proposed livestock use? (Grazing Management Guidelines, Tech Notes, Range 35, Appendix E)
    - Precipitation record (recent climate history) for that site if available or an average of records from similar sites. (How many years of continuous drought?)
    - Has precipitation returned to normal? Compared to previous deficits?
3. Has plant mortality affected the amount of forage available?
    - Physical evidence of plant carcasses in relationship to live plants.
    - Utilize trend studies or other site-specific data and information.

- Identify and use research about rangeland recovery.

4. Is adequate forage available, in suitable areas, to support the proposed livestock use while providing for improved watershed conditions and wildlife use or other consumptive uses like Wild Horse and Burros?
   - Is the grazing unit in a pasture system? Are there residual feed sources on rested units?
   - Does the grazing unit have unused areas that may be utilized by prescribing special terms and conditions?

Assessment criteria for evaluating potential management actions

1. What is the proposed season-of-use? (Extended livestock use during the growing season could further stress plants and reduce plant vigor.)
   - History of season of use. Have there been temporary reductions in use in past years? If so, what time of the year? Duration? Environmental results?
   - Are there unused forage reserves or allotments within the jurisdiction?
2. What additional monitoring will be required to assure that the scheduled use can be accommodated and how will it be accomplished
   - Does the office have the staffing to support additional monitoring?
   - What will the office have to give up (units of accomplishments) to conduct additional monitoring?
   - Are there other options for staffing a short term monitoring program? (i.e.: "Borrowing" vegetative experts from other agencies, grad students, etc.)
3. What is an appropriate level of use before livestock should be removed?
   - Stubble height (Grazing Management Guidelines, Tech Notes, Range 34, Appendix E)
   - Measure litter against open surface. Is there adequate litter (% based on soil inventories for that site) to protect soil moisture?
4. Is adequate water available for the livestock or will they congregate on a few watering areas?
   - Are there water sources in areas not traditionally grazed?
   - Is there road access to accommodate water hauling?
   - What is the [permittee] maintenance record for maintaining water systems and dirt tanks?
5. What is the track record and capability of the permittee to accommodate special permit terms and conditions? (water hauling, herding, etc.)
6. Encourage voluntary adjustments in livestock use, as it becomes apparent that normal grazing schedules would result in degradation of long-term resource productivity and subsequent economic impacts to the permittee.

While these assessment criteria (questions) are grazing program specific they can and should be modified as needed to assess the capability of public lands to sustain other uses, such as cross-country travel, special recreation permits, etc.

Site Specific Assessment Guidelines—Mid-Term (after spring and summer seasons 2003 through winter 2004)

Recovery will be slow even with average winter moisture. Water sources will continue to be limited and forage production and availability will be delayed as the key forage species recover from the stress caused by the drought. Consider the following actions in preparing for future grazing activities:

- Consider competitive uses from horses and wildlife especially elk when allocating livestock use. Hold inter-agency and public meetings to identify issues and options for mitigation.
- Discuss future utilization levels and options with the permittee if utilization levels are met or exceeded in the short-term.
- Encourage voluntary adjustments in livestock use as it becomes apparent that normal grazing schedules would result in degradation of long-term resource productivity.
- Consider increased workloads or changes in priorities (FY 2003/2004) resulting from drought mitigation.
- Chart precipitation history. Have precipitation levels returned to normal or above for a long enough period to return to permitted levels of use?
- Use Standardized Precipitation Index, Palmer Drought Severity Index, and other tools list in Appendix E to determine climate trends.

Site Specific Assessment Guidelines—Long-term

Due to the extended nature and severity of the drought, changes in plant composition may occur or have occurred already. Changes are variable between sites and may include; conversion from cool to warm season grasses, increased or decreased shrub components, decreased grass production, increase in bare ground and the invasion of non-native plants. Depending on local conditions, changes in vegetation conditions may decrease the amount of forage available for livestock, wild horses or elk as well as other grazers and browsers. These changes would be long term and may require adjustments in future allocations. Field offices should be aware of this possibility and make changes as appropriate in their monitoring and assessment of these areas.

Strategies for Management—Outreach

The most immediate need is to visit with permittees prior to spring and summer use (2003). Ideally permittees who graze on both USFS and BLM would meet with USFS and BLM staff and leadership at the same time to discuss options.

Other permitted uses, such as outfitters and guide activities, cross-country OHV use, etc. should be evaluated for short-term impacts from drought. Agency staff and leadership should meet with Outfitters and Guides, etc. to discuss short and long-term drought impacts.

In late winter, the agencies should conduct joint meetings with grazing permittees to outline short-term actions.

The DA&MT recommends that public information meetings be held across the state (spring and summer) to identify issues and potential mitigations. Dr. Roger Banner--USU Extension, best describes the concept: “Plan for drought during the good years.”

The team has identified a number of partnerships that could be utilized to conduct these meetings such as the RC&D Councils, The Utah Rural Economic Council, The Colorado Plateau Forum, and others.

There appears to be a conflict with wildlife, especially big game species. Resource managers and private landowners report that wildlife (primarily elk) have had major impacts, especially in a drought, on rested pastures, resources reserves, private lands, and riparian areas. Therefore it is recommended that after the public information meetings that agency officials (Utah Partners for Conservation and Development) meet to resolve the wildlife/livestock public land issue. Furthermore we recommend that these agencies or a combination of affected partners meet with private landowners to identify issues, share science, and find potential mitigations to resolve the issue.

In those areas where wild horse herds are found, the agencies should hold public information meetings (mid-summer 2003) to discuss issues and possible mitigation.

There is a natural assumption to believe that a drought is over when "normal" precipitation averages return. And while the drought may indeed be broken, drought impacts, especially from a prolonged cycle, will not be immediately repaired. Given the duration of this cycle and its intensity, it is suggested that the Utah Partners for Conservation and Development plan and hold joint briefings with the following to discuss common positions:

- Utah Farm Bureau
- SITLA
- Utah Cattlemen's
- Utah Wool Growers
- Utah Association of Counties
- Utah Congressional Delegation
- Governor of Utah [NOTE: if the land management agencies enact either voluntary or other grazing reductions, it may be in the best interests of the State if an emergency drought designation is continued in Utah at least through 2003.]
- Joint news conferences
- NGO's with public land interests (e.g. OHV, wildlife, wilderness, etc.)
- Tribes

Recommendations—Long Term

The DA&MT suggests that a multi-agency, multi-disciplinary team be named immediately to gather climate data on a regular basis, at least yearly, to determine if drought is eminent.

One of the remaining tasks of the DA&MT is form sub-teams to develop strategies for the following in 2003.

A. Science: while there is a quantity of research that has been conducted on drought and drought impacts, most of this information is kept by the university that conducted the research. A compendium of known science and an annotated bibliography should be created for Utah. The science strategy would then focus on peer review of existing science, deployment of implementable research, and identifying science gaps and needs for future research. A joint funding strategy would be another product.

B. Early detection: there are a number of tools (Appendix E) that can be used for early detection of drought. In addition there are new methodologies, such as remote sensing, that could be applied. The strategy would also focus on identification of environmental triggers. Early intervention: because drought causes strife, it is important for the agencies to identify drought early and implement early "warning" meetings with public land users. The principles of ADR should be utilized. The strategy will identify these tools and develop a methodology for deployment.

C. Incorporation of multi-agency strategies in LUPs: this goes beyond the next section of this document. LUPs regardless of jurisdiction must be mutually supportive. A strategy for inclusion of these findings into existing land use plans and new plans is needed. Climate as a baseline component is missing from most LUP's. Some plans use climate to analyze alternatives and uses but climate must be an integral part of the process from beginning to end.

D. This multi-agency drought assessment and mitigation effort should be combined with the Governor's plan and with any other existing drought plans. In addition it is highly recommended that a statewide (multi-agency/entity) team be named to prepare a statewide drought assessment and mitigation plan. A suggested format for a statewide plan is included in Appendix F.

[i] Western Regional Climate Center
[ii] Solley, W.B., Pierce, R.R., & Perlman, H.A., 1993, Estimated use of water in the United States in 1990: USGS Circular 1081, 76p. and Solley, W.B., Pierce, R.R., & Perlman, H.A., 1998, Estimated use of water in the United States in 1995: USGS Circular 1200, 71p.

[iii] David Grider, Planning for Drought in Utah, Power Point Presentation December, 2002
[iv] "Radio West" Interview with Doug Fabrezzio, Utah in Drought July, 2002 NPR
[v] Rouse, G, Guinn, K, Madsen, C, August 1994, How Cool Season Grasses Grow and Plant Needs: Technical Notes, Range 35, USDA, Soil Conservation Service
[vi] Bowns, J., Dr, from a presentation on recovery, Feb. 2003, BLM Richfield, UT.
[vii] Warr G., Personal Conversation, August, 2002
[viii] , USU Extension agent, county, September, 2002
[ix] Randy Parker, unpublished document, Utah Department of Agriculture, 2002
[x] Jamie Dalton, unpublished report, Utah Department of Parks and Recreation, December, 2002
[xi] Del Lafevre, personal conversation with the DAMT, September, 2002

Utah Partners for Conservation and Development

DROUGHT ASSESSMENT AND MITIGATION
A STATE OF THE STATE REPORT
AN MULTI-AGENCY/MULTI-DISCIPLINARY TEAM APPROACH TO EARLY ASSESSMENT, EARLY INTERVENTION, AND PLANNING

EXECUTIVE SUMMARY

Drought is an insidious and recurring natural event that crosses all political boundaries and ownerships, impacting the land, the economy, and society.

Utah is an Arid Place

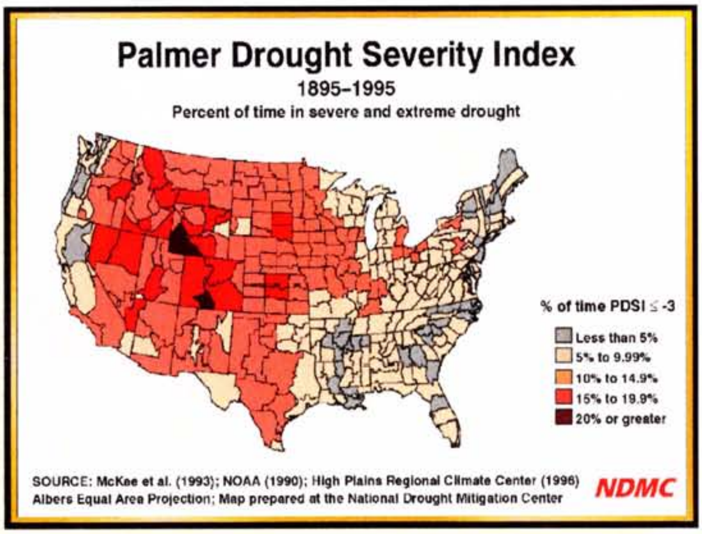
Drought is not the norm in Utah but it is a recurring climatic factor that, depending on its duration, can have extreme economic, social, and environmental impacts. Drought is generally impossible to predict and hard to detect until the signs of its presence are impossible to miss. The state of Utah is entering the fifth year (2003) of a drought that by some standards is potentially even more devastating than the drought of the fifties or even the "dust bowl." This is due in part to significant changes in population, demographics, and, on public lands, changes in uses and user preferences.

Drought on Public Lands 2002

All parts of the state have been hit by this drought cycle including public lands which make up a significant part of the state. All uses that occur on public lands have been impacted. Impacts include severe multi-species plant mortality on some sites, record low flows in rivers, streams, and springs, mortality and poor reproduction in some big game species, increased danger of catastrophic fires that threaten homes and habitat, and increased opportunities for invasion by opportunistic weedy species, annual grasses, and insects. The result: significant environmental issues on public lands, collateral impacts to private and state lands, and direct impacts to rural and statewide economies.

Cooperation is the Key to Drought Mitigation

The impacts of future drought cycles can be partially mitigated by cooperative partnerships between state and federal agencies, tribes, public land users, and the Governors Office. This can be accomplished by forming multi-agency, multi-disciplinary teams to identify and implement early detection and early intervention strategies. These instruments use a statewide drought mitigation plan and agency Land Use Plans as a base to launch mitigation early in a drought cycle. They lay out a systematic approach to insure that the critical recovery phase is factored into land use decisions. Teams will also identify survival tools and education opportunities that help private landowners and public land users plan for changes in use during drought cycles.



Next Steps

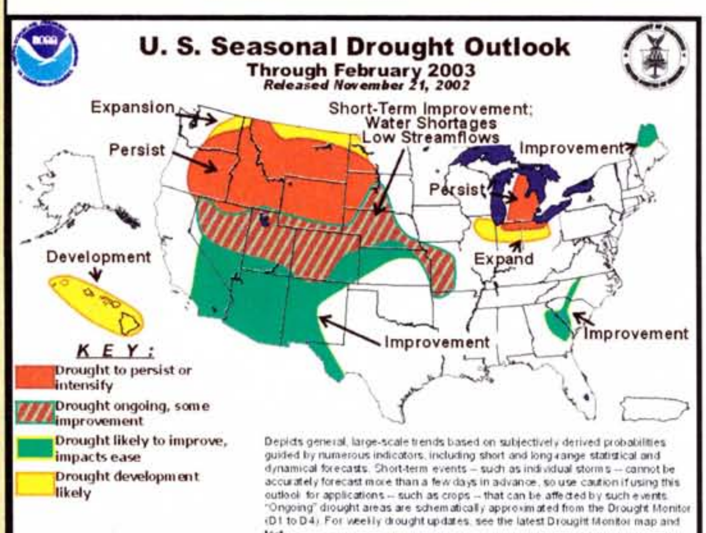
The federal and state partners in the Utah Partners for Conservation and Development have been working diligently to seek solutions that may help mitigate the impacts of drought. All have been in contact daily with various public land users. But tough and unpopular decisions have been and will continue to be made. These decisions will have impacts across the spectrum of public land programs and will resonate in regional economies. Strategies for developing a statewide drought plan, early detection triggers, and early intervention processes are being developed so that we can, collectively, start mitigating drought related issues sooner in a cycle. The team is identifying science and other tools that will help detect and alleviate the impacts of drought. The Utah Partners for Conservation and Development are committed to work cooperatively and keep the lines of communication open to all pubic land users to help reduce the impacts of drought on public land users.

The Science of Recovery

It is human nature to want to return to normal as quickly as possible. Therefore, after a prolonged drought, we look at a return to normal precipitation as the end of the drought. Some immediate indicators include green pastures and full reservoirs. But the real effects of drought on the economy and the environment can be hard to see. For example we do not see, after several years of drought, that even though a plant is green it lacks vigor and that the overall biomass of the site has been reduced, therefore, land use may have to continue at a reduced level for a while longer. In addition, soil moisture is so low that it does little to promote plant recovery, springs are slow to recover, and wildlife and livestock births are very low until they recover. Many public land users have taken reductions in use and will probably continue to do so, at least in the short term. The Partners are seeking and implementing the best science that can be found for making decisions. But the best tool has been one-on-one conversations with public land users discussing the recovery process and the possible ramifications and impacts.

Bottom Line

Recovery will not happen immediately following the first normal precipitation cycle. Both public land managers and public land users are faced with some tough decisions. It will take teamwork, science, and above all, time, patience, and communication to mitigate the economic, social, and environmental impacts of drought.



APPENDIX A

What is Drought?

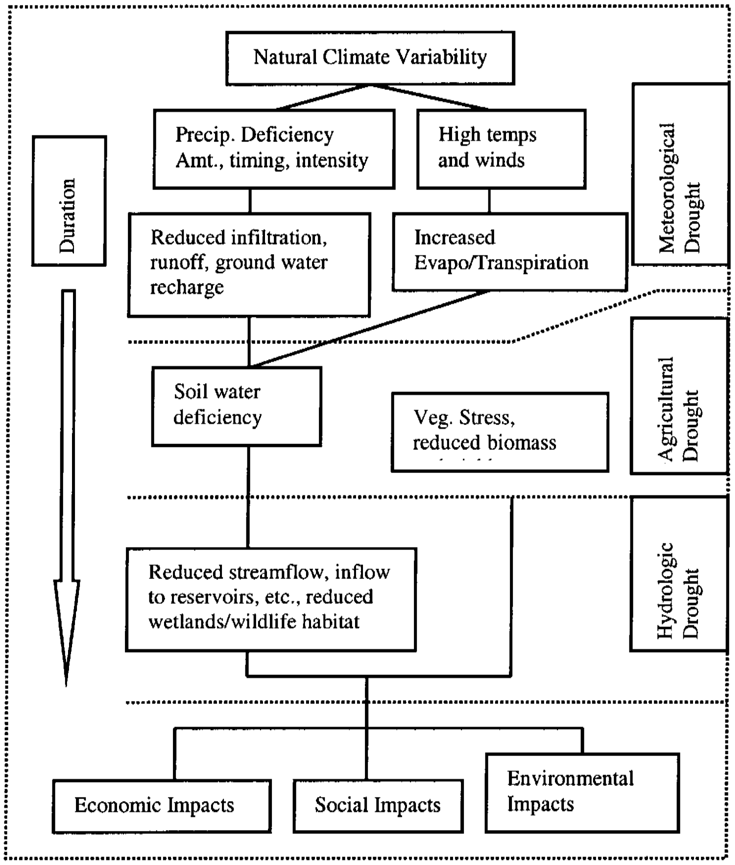
Drought is unique among natural hazards because it is not a clear event like a flood, earthquake, hurricane, or tornado. These events strike, leave their mark, and are gone. A drought, however, is insidious. It sneaks up disguised as several weeks of sunny days or a winter with little snow. Unlike a hurricane, we cannot follow its course on a map. Generally we are not sure when a drought began until it is already underway, and often we are unsure when it ends. Often we are fooled by the return of a "normal" or above normal winter, or in Utah, by summer "monsoon" rains that bring green to a parched landscape. However, any day when it doesn't rain or snow (which describes most days in Utah) could be the beginning of the next drought.

> "We have no good definition of drought. We may say truthfully that we scarcely know a drought when we see one. We welcome the first clear day after a rainy spell. Rainless days continue for a time and we are pleased to have a long spell of such fine weather. It keeps on and we are a little worried. A few days more and we are really in trouble. The first rainless day in a spell of fine weather contributes as much to the drought as the last, but no one knows how serious it will be until the last dry day is gone and the rains have come again... we are not sure about it until the crops have withered and died."[i]

Drought has often been referred to as a creeping disaster because the lack of sufficient moisture can lead to profound implications for the environment and all segments of society. However, drought may affect each segment differently and be highly variable in its severity and magnitude on each segment. The reason for this variability is the lack of a clear and concise definition of drought that is applicable to all disciplines.

A drought is a period of abnormally dry weather that persists long enough to produce a serious hydrologic imbalance (for example crop damage, water supply shortage, etc.) The severity of the drought depends upon the degree of moisture deficiency, the duration and the size of the affected area.

There are four main types of drought:



- Meteorological – is based on a specified time period with precipitation averaging below a critical threshold. Due to climatic differences what is considered a drought in one location may not be a drought in another location.
- Agricultural - refers to a situation when the amount of moisture in the soil no longer meets the needs of a particular crop.
- Hydrological - occurs when surface and subsurface water supplies are below normal.
- Societal or economic – a complex interaction of the natural phenomenon, environmental degradation, and human impact.

The wide variety of disciplines affected by drought, its diverse geographical and temporal distribution, and the many scales drought operates on make it difficult to develop both a definitions to describe drought and an index to measure it.

Common to all types of drought is the fact that they originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (say, a few weeks or a couple months), the drought is considered short-term. But if the weather or atmospheric circulation pattern becomes entrenched and the precipitation deficits last for several months to several years, the drought is considered to be a long-term drought. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought. Many quantitative measures of drought have been developed in the United States, depending on the discipline affected, the region being considered, and the particular application.

Several indices developed by Wayne Palmer, as well as the Standardized Precipitation Index, are useful for describing the many scales of drought.
The Palmer Z Index measures short-term drought on a monthly scale. The Palmer Crop Moisture Index (CMI) measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season.

The Palmer Drought Severity Index (PDSI) (known operationally as the Palmer Drought Index (PDI)) attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change almost literally overnight from a long-term drought pattern to a long-term wet pattern, the PDSI (PDI) can respond fairly rapidly.

The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The Palmer Hydrological Drought Index (PHDI), another long-term drought index, was developed to quantify these hydrological effects. The PHDI responds more slowly to changing conditions than the PDSI (PDI).

While Palmer's indices are water balance indices that consider water supply (precipitation), demand (Evapo-transpiration) and loss (runoff), the Standardized Precipitation Index (SPI) is a probability index that considers only precipitation.

The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI is computed by NCDC for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought.

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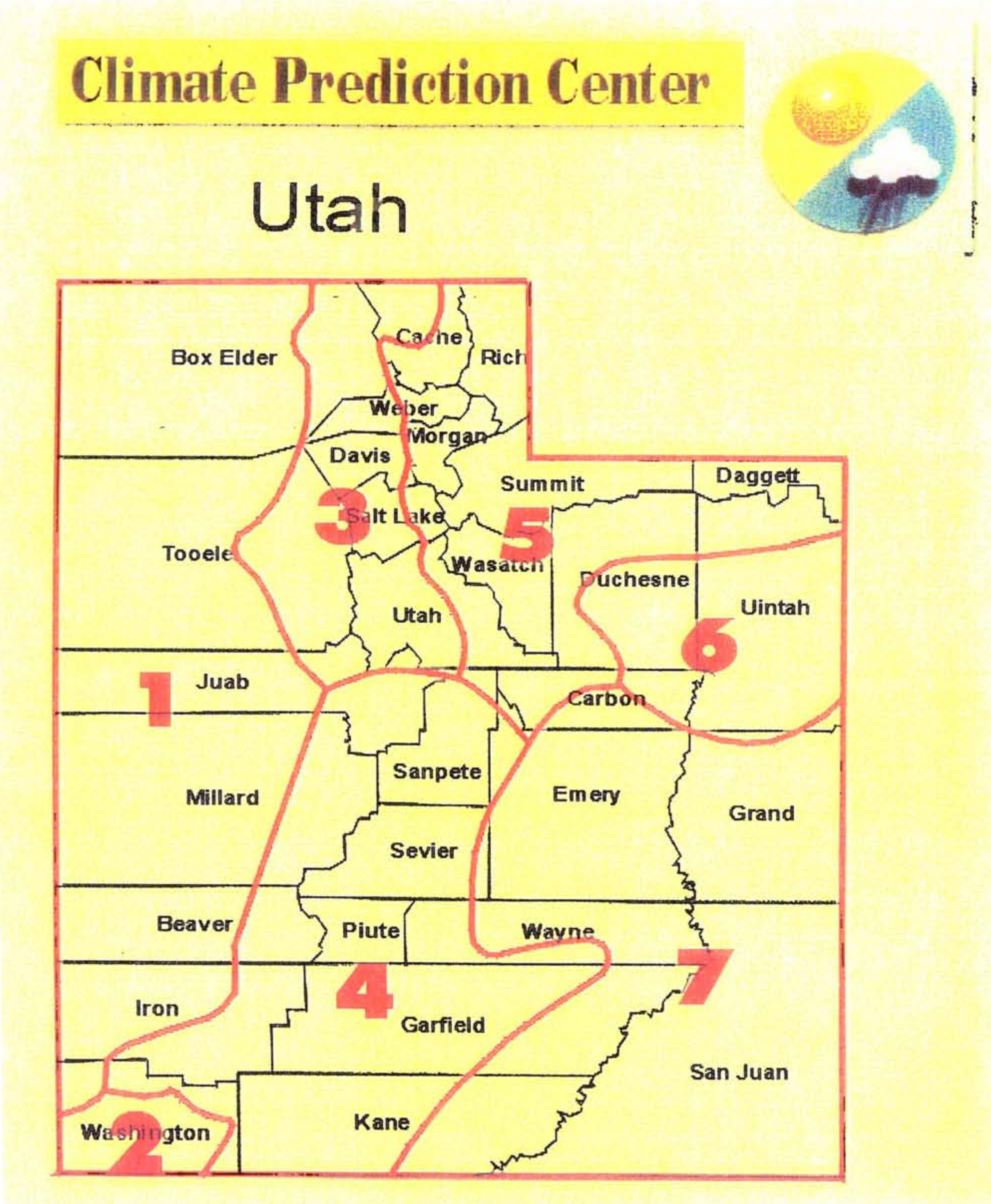
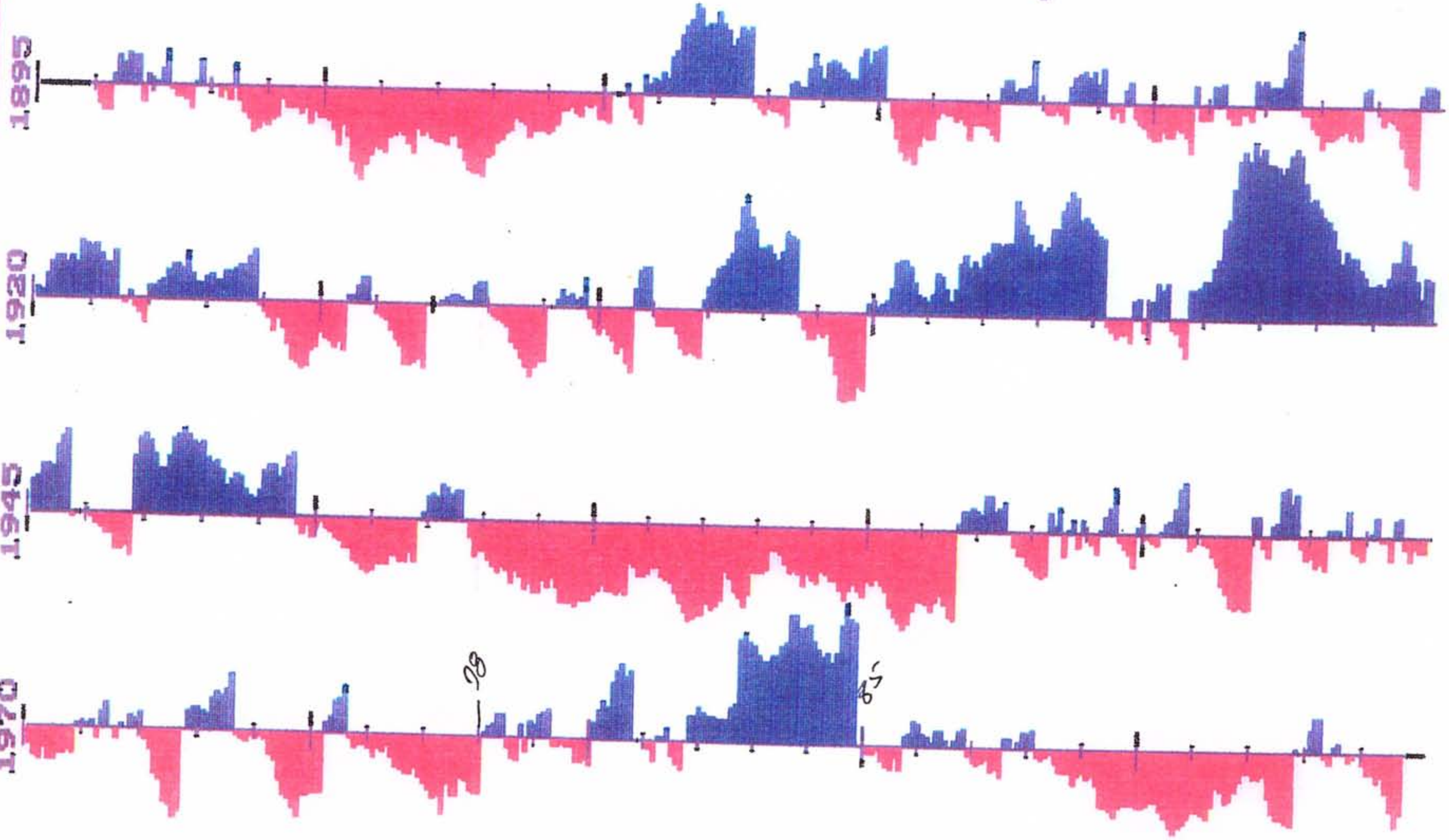
[i] Tannehill, Drought and Its Causes and Effects, (1947)

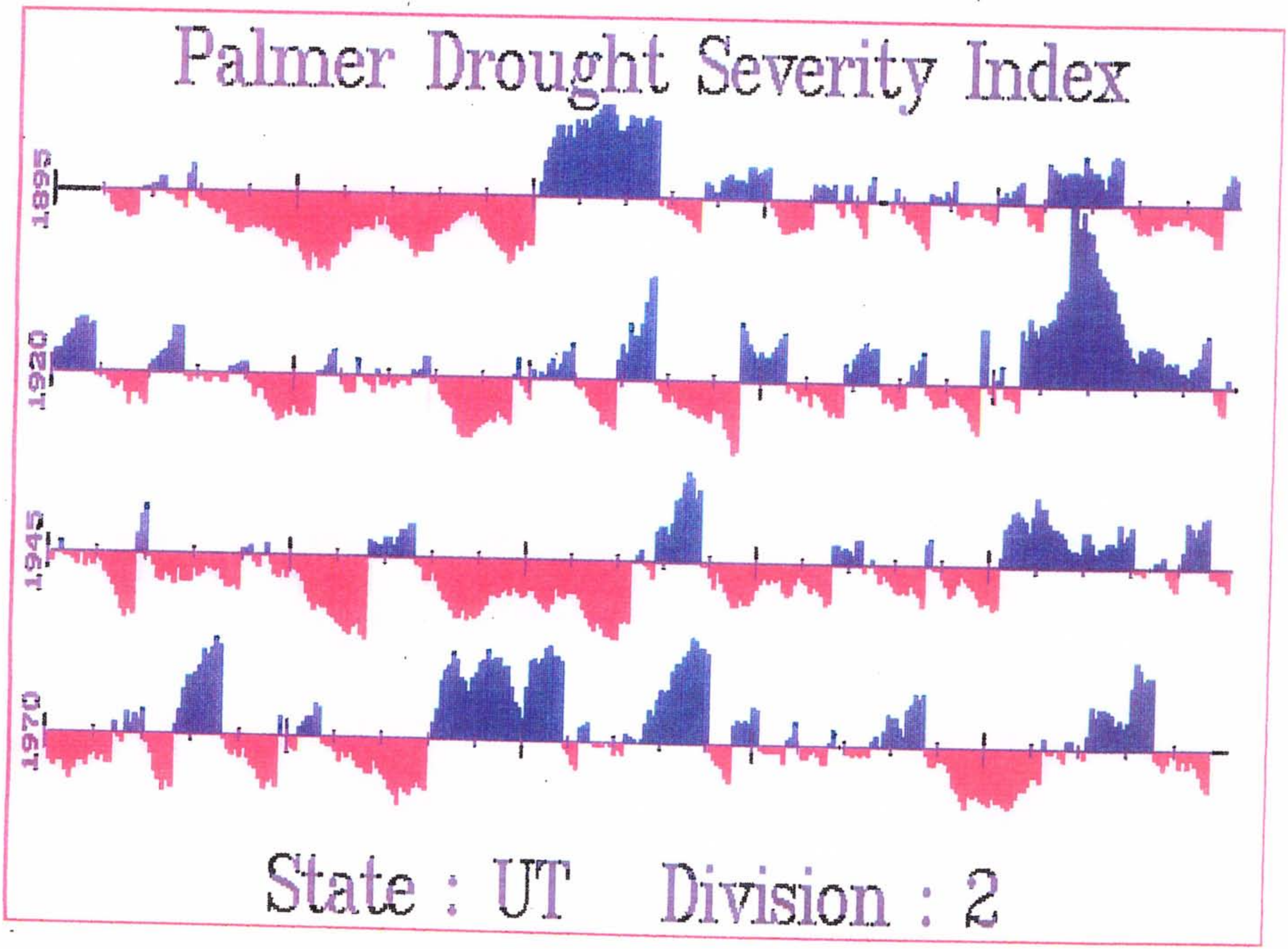
APPENDIX B
Historic Climate patterns in Utah
PALMER DROUGHT INDEX GRAPHS



Palmer Drought Severity Index

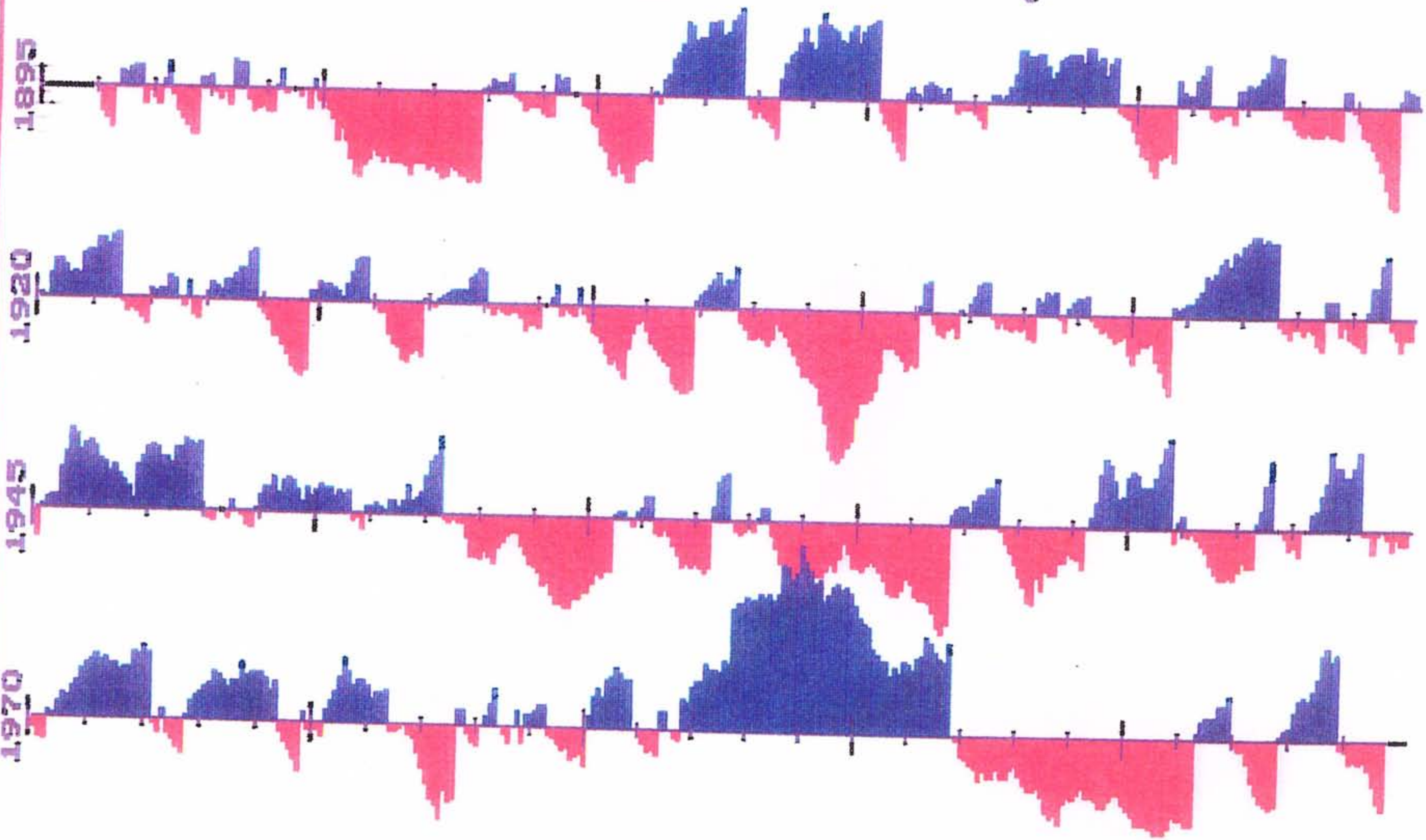


State : UT Division : 1



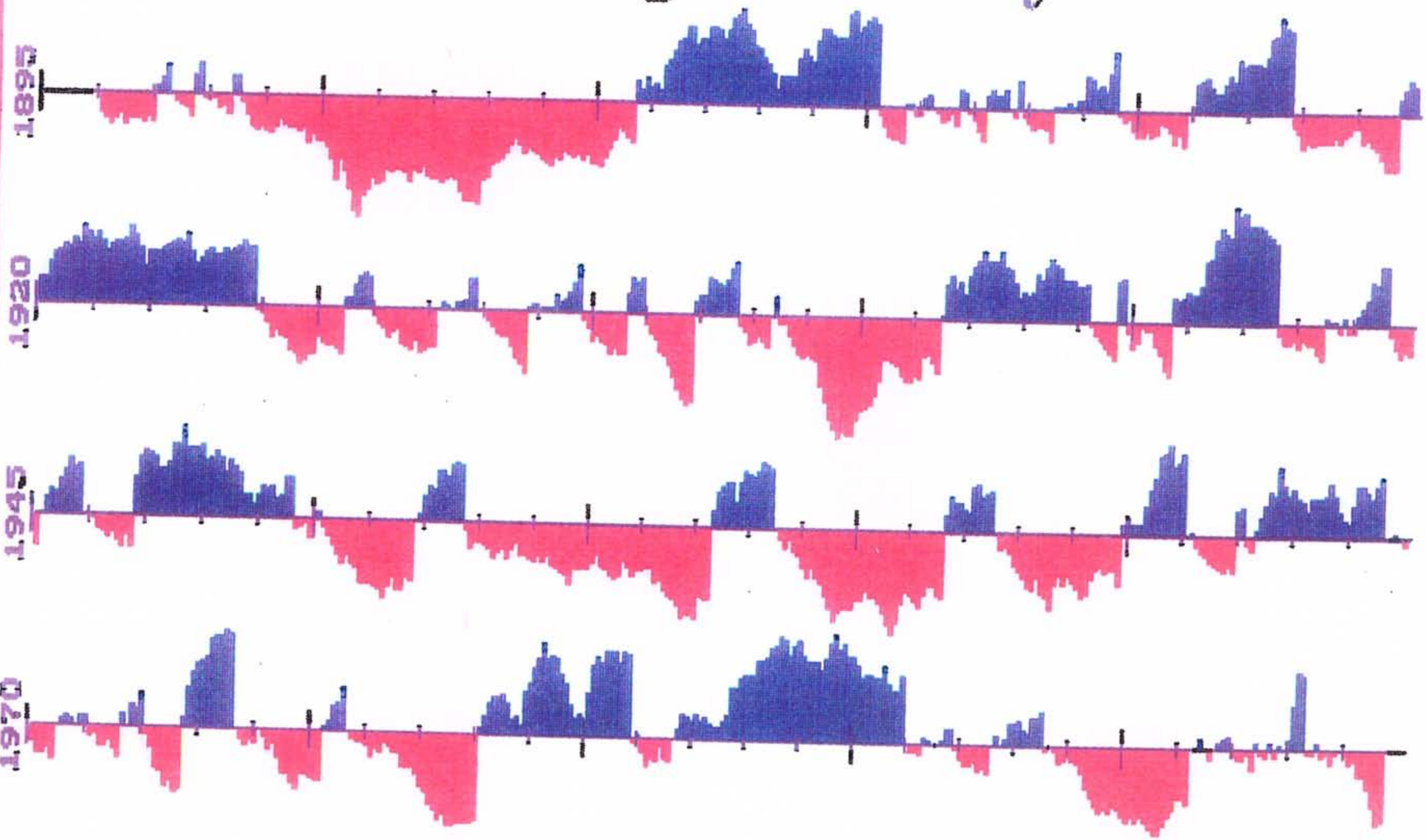
Palmer Drought Severity Index
1895
1920
1945
1970
State : UT Division : 2

Palmer Drought Severity Index



State : UT Division : 3

Palmer Drought Severity Index



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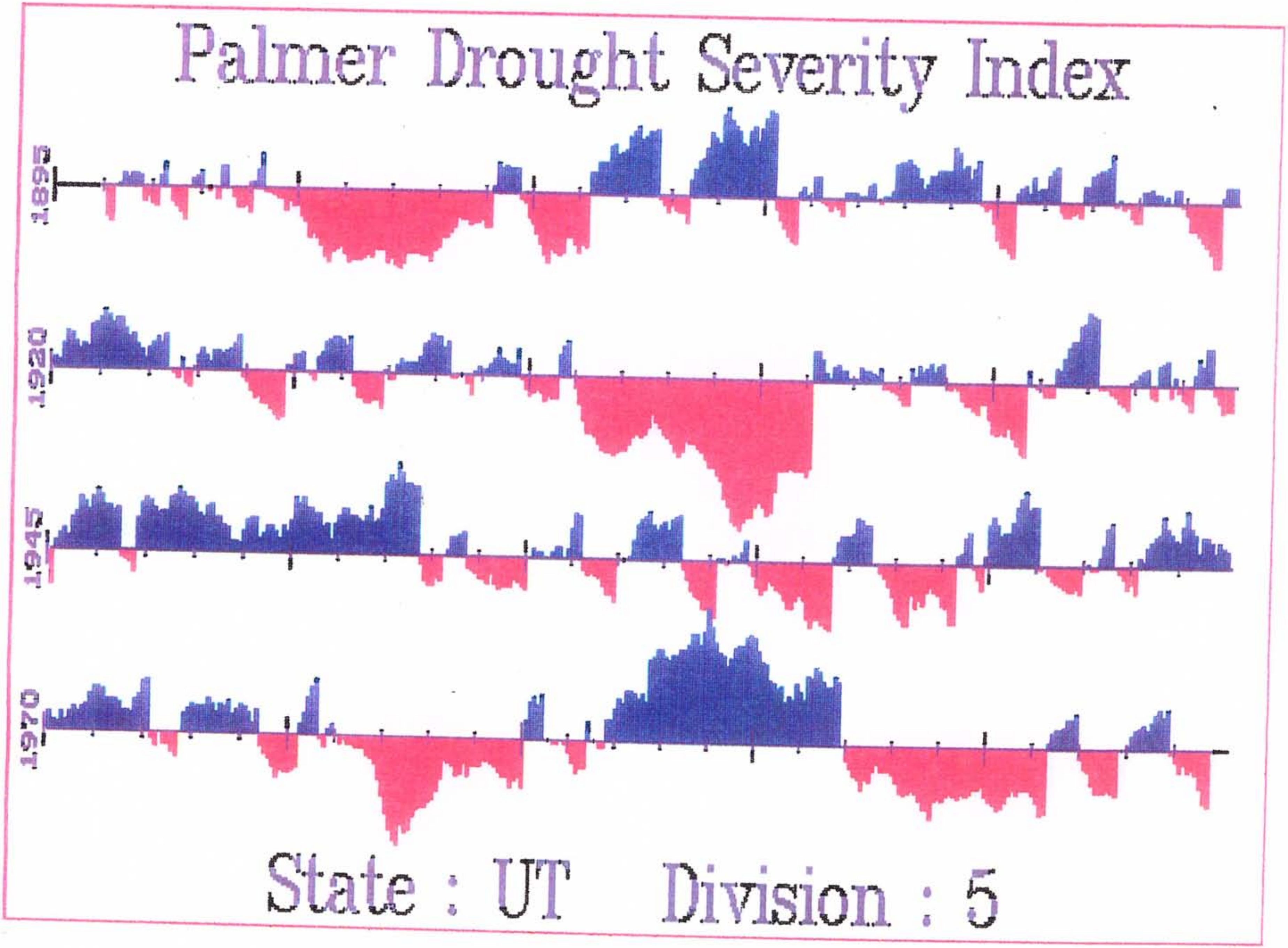
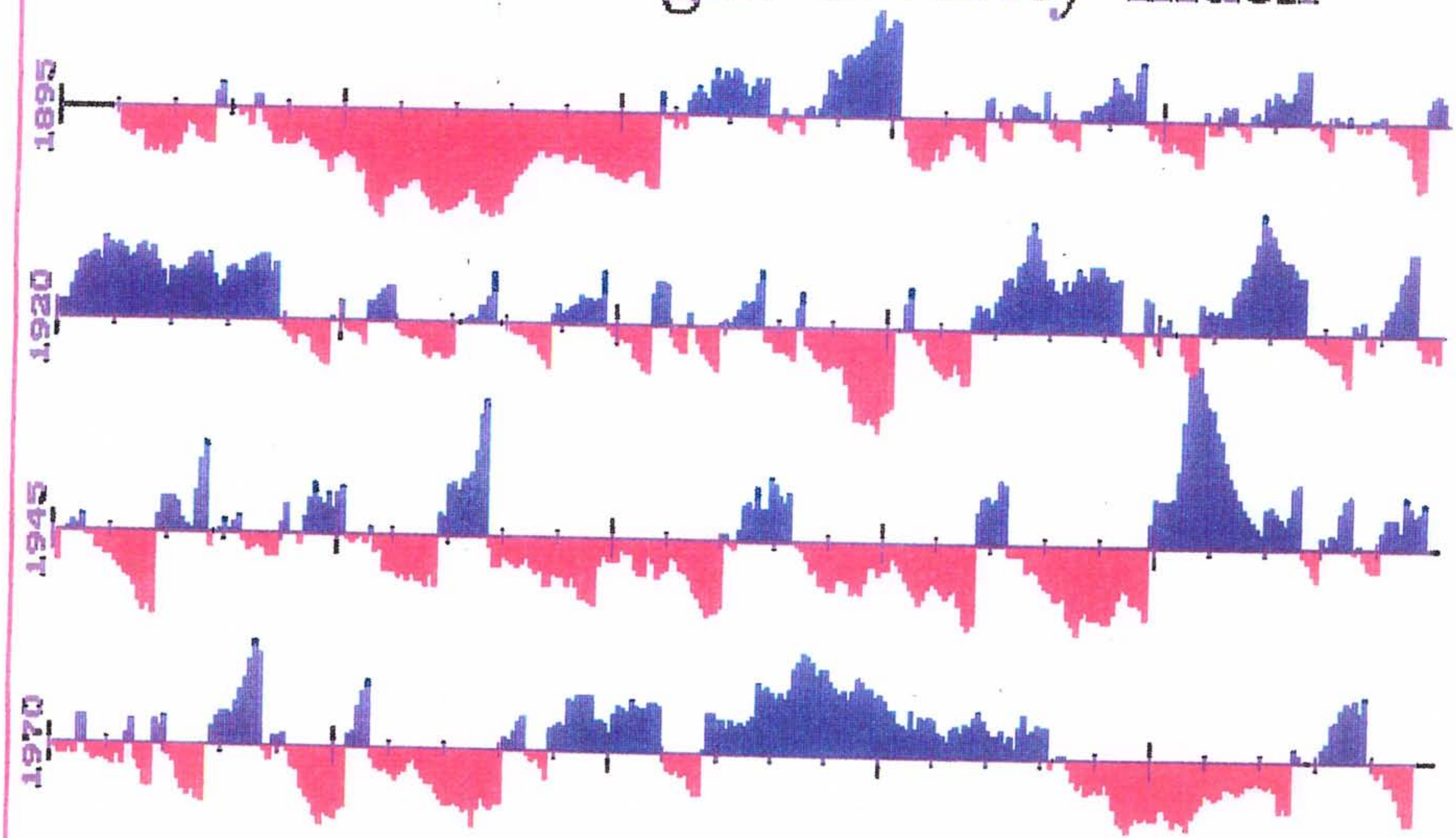


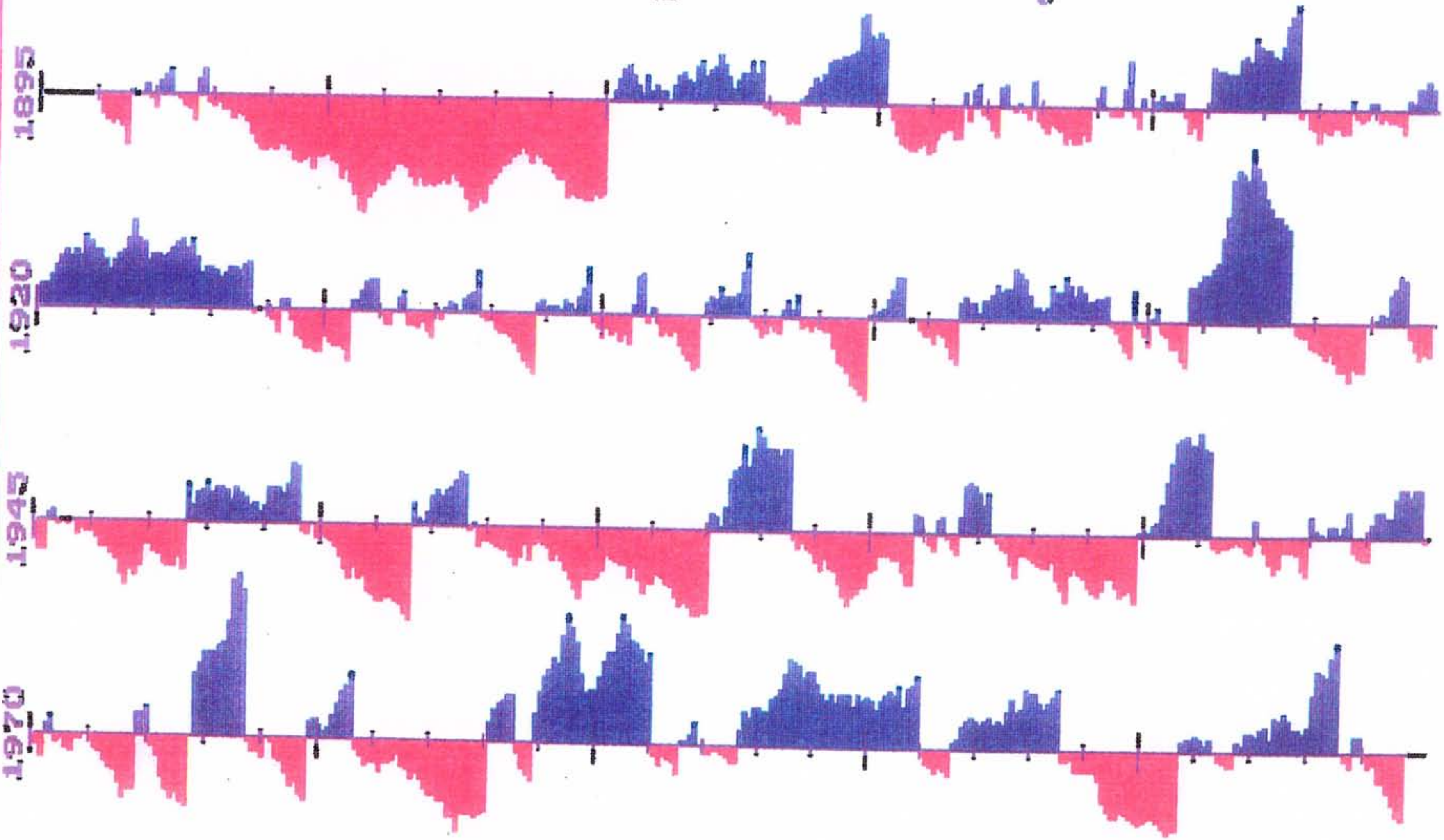
Palmer Drought Severity Index
1895
1920
1945
1970
State : UT Division : 5

Palmer Drought Severity Index



State : UT Division : 6

Palmer Drought Severity Index



State : UT Division : 7

Appendix C

Impacts of Drought

Drought produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to our ability to produce goods and provide services. Impacts are commonly referred to as direct or indirect. Reduced crop, rangeland, and forest productivity; increased fire hazard; reduced water levels; increased livestock and wildlife mortality rates; and damage to wildlife and fish habitat are a few examples of direct impacts. The consequences of these impacts illustrate indirect impacts. For example, a reduction in crop, rangeland, and forest productivity may result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced tax revenues because of reduced expenditures, increased crime, foreclosures on bank loans to farmers and businesses, migration, and disaster relief programs. Direct or primary impacts are usually biophysical. Conceptually speaking, the more removed the impact from the cause, the more complex the link to the cause. In fact, the web of impacts becomes so diffuse that it is very difficult to come up with financial estimates of damages. The impacts of drought can be categorized as economic, environmental, or social.

Not all impacts of drought are negative. Some agricultural producers outside the drought area or with surpluses benefit from higher prices, as do businesses that provide water-related services or alternatives to water-dependent services; these types of businesses were among the "winners" in the 1987–89 U.S. drought. Those producers in Utah who were able to grow hay in 2002 saw hay prices reach as high as $120 per ton. While clearly a positive impact to the hay producer, it hit livestock producers who were considering feeding hay very hard, further complicating already difficult decisions. Many economic impacts occur in agriculture and related sectors, including forestry and fisheries, because of the reliance of these sectors on surface and subsurface water supplies. In addition to obvious losses in yields both in crop and livestock production, drought is associated with increases in insect infestations, plant disease, and wind erosion.

Prolonged drought exacerbates issues with historic timber management regimes that have resulted in extra-ordinary fuel loads. These sites are easily stressed by drought, which makes them highly susceptible to insects and disease. The incidence of forest and range fires increases substantially during extended droughts, which in turn places both human and wildlife populations at higher levels of risk.

Hydropower production may also be curtailed significantly.

Impacts from Drought--Economic

Income loss is a crucial indicator used in assessing the impacts of drought because so many sectors are affected. Reduced income for farmers has a ripple effect. Retailers and others who provide goods and services to farmer's face reduced business. This leads to unemployment, increased credit risk for financial institutions, capital shortfalls, and loss of tax revenue for local, state, and federal government. Less discretionary income affects the recreation and tourism industries. Prices for food, energy, and other products increase as supplies are reduced. In some cases, local shortages of certain goods result in the need to import these goods from outside the stricken region. Reduced water supply impairs the navigability of rivers and results in increased transportation costs because products must be transported by rail or truck. Utah does not have navigable rivers but when drought does impact rivers elsewhere, Utah citizens pay higher costs for rail and truck transportation.
The following are potential impacts that may or may not impact Utah.

Potential costs and losses to agricultural producers

- Annual and perennial crop losses
- Damage to crop quality
- Income loss for farmers due to reduced crop yields
- Reduced productivity of cropland (wind erosion, long-term loss of organic matter, etc.)
- Insect infestation and plant disease Wildlife damage to crops Increased irrigation costs
- Cost of new or supplemental water resource development (wells, dams, pipelines)

Costs and losses to livestock producers

- Reduced productivity of rangeland
- Reduced milk production
- Forced reduction of foundation stock (serious issue in Utah)
- Closure/limitation of public lands to grazing
- High cost/unavailability of water for livestock
- Cost of new or supplemental water resource development (wells, dams, pipelines)
- High cost/unavailability of feed for livestock
- Increased feed transportation costs
- High livestock mortality rates
- Disruption of reproduction cycles (delayed breeding, more miscarriages)
- Decreased stock weights (weaning weights)
- Increased predation
- Range fires (loss of additional habitat and forage)

Loss from timber and woodland production

- Wildland fires

- Tree disease
- Insect infestation (Ips confusus infestation in Four-corners—Pinyon)
- Impaired productivity of forest land
- Direct loss of trees, especially young ones (drought exacerbated mortality)

General economic effects

- Decreased land prices
- Loss to industries directly dependent on agricultural production (e.g., machinery and fertilizer manufacturers, food processors, dairies, etc.)
- Unemployment from drought-related declines in production
- Strain on financial institutions (foreclosures, more credit risk, capital shortfalls)
- Revenue losses to federal, state, and local governments (from reduced tax base)
- Reduction of economic development
- Fewer agricultural producers (due to bankruptcies, new occupations)
- Rural population loss
- Loss to recreation and tourism industry
- Loss to manufacturers and sellers of recreational equipment
- Losses related to curtailed activities: hunting and fishing, bird watching, boating, etc.

Energy-related effects

- Increased energy demand and reduced supply because of drought-related power curtailments
- Costs to energy industry and consumers associated with substituting more expensive fuels (oil) for hydroelectric power

Water Suppliers

- Revenue shortfalls and/or windfall profits
- Cost of water transport or transfer
- Cost of new or supplemental water resource development

Transportation Industry

- Decline in food production/disrupted food supply
- Increased importation of food (higher costs)

Impacts from Drought--Social

Social impacts mainly involve public safety, health, conflicts between water users, reduced quality of life, and inequities in the distribution of impacts and disaster relief. Most of the impacts specified as economic and environmental have social components as well. Globally, population out-migration is a significant problem in many countries, often stimulated by greater availability of food and water elsewhere. Migration is usually to urban areas within the stressed area or to regions outside the drought area; migration may even be too adjacent countries, creating refugee problems. In Utah, drought related farm and business failures also frequently lead to out-migration, usually to urban areas in the state and sometimes to other states. However, when the drought has abated, these persons (globally or in Utah) seldom return home, depriving rural areas of valuable human resources necessary for economic development. While little data about drought caused out-migration is available for Utah, it is recognized at least anecdotally.

"Our single largest export from Garfield County are our children followed by families who can't make a living wage."[i]

For the urban area to which they have immigrated, they place ever-increasing pressure on the social infrastructure, possibly leading to greater poverty and social unrest. Social impacts—some may or may not apply in Utah--include the following:

Health

- Mental and physical stress (e.g., anxiety, depression, loss of security, domestic violence)
- Health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations, reduced fire fighting capability, etc.)
- Reductions in nutrition (e.g., high-cost food limitations, stress-related dietary deficiencies)
- Loss of human life (e.g., from heat stress, suicides)
- Public safety from forest and range fires
- Increased respiratory ailments
- Increased disease caused by wildlife concentrations

Conflicts

- Water user conflicts (institutional restraints on water use)
- Political conflicts (public dissatisfaction with government drought response)
- Management conflicts (public dissatisfaction with government drought response)
- Other social conflicts (e.g., scientific, media-based)

Reduced quality of life, changes in lifestyle

- Increased poverty in general
- Population migrations (rural to urban areas)
- Loss of aesthetic values
- Reduction or modification of recreational activities

Miscellaneous

- Disruption of cultural belief systems (e.g., religious and scientific views of natural hazards)
- Reevaluation of social values (e.g., priorities, needs, rights)
- Perceptions of inequity in relief, possibly related to socioeconomic status, ethnicity, age, gender, seniority
- Loss of cultural sites
- Increased data/information needs, coordination of dissemination activities

Impacts from Drought--Environmental

Environmental losses are the result of damage to plant and animal species, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity of the landscape. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

Not all of the following impacts have occurred in Utah; however, the list may not include others that have.

Damage to animal species

- Reduction and degradation of fish and wildlife habitat (loss of fish and other aquatic organisms due to decreased flows)
- Lack of feed and drinking water
- Greater mortality due to increased contact with agricultural producers, as animals seek food from farms and producers are less tolerant of the intrusion
- Disease
- Increased vulnerability to predation (from species concentrated near water)
- Migration and concentration (loss of wildlife in some areas and too many wildlife in other areas)
- Increased stress to endangered species
- Loss of biodiversity

Hydrological effects

- Lower water levels in reservoirs, lakes, and ponds
- Reduced flow from springs
- Reduced streamflow
- Loss of wetlands
- Estuarine impacts (e.g., changes in salinity levels)

- Increased groundwater depletion, land subsidence, reduced recharge
- Water quality effects (e.g., salt concentration, increased water temperature, pH, dissolved oxygen, turbidity)

<u>Damage to plant communities</u>

- Loss of biodiversity
- Loss of trees from urban landscapes, shelterbelts, wooded conservation areas
- Loss of preferred stand density through plant mortality (lose not only forage production but also infiltration of water—impacts to aquifers)
- Conversion from cool season to warm season species (a probable consequence of diminished spring moisture—over several sequential years--and normal yearly summer monsoon precipitation)
- Composition changes through invasion by more aggressive and drought tolerant exotic species (grasses, forbs, shrubs, and trees)
- Increased number and severity of fires due to low fuel moisture caused by extended drought
- Wind and water erosion of soils, reduced soil quality
- Air quality effects (e.g., dust, pollutants)
- Visual and landscape quality (e.g., dust, vegetative cover, etc.)

This drought cycle, especially during 2002, has clearly impacted the state of Utah in a variety of ways. Some areas like the southeastern corner of the state have experienced more than perhaps the northwestern corner. Yet the cumulative impact from this cycle will be felt by Utahn's for years to come.

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[i] Louise Liston, Introductory remarks at NACo, 1997

Appendix D

Utah Bureau of Land Management Standards and Guidelines

A. Standard 1. Upland soils exhibit permeability and infiltration rates that sustain or improve site productivity, considering the soil type, climate, and landform.
As indicated by:

a) Sufficient cover and litter to protect the soil surface from excessive water and wind erosion, promote infiltration, detain surface flow, and retard soil moisture loss by evaporation.

b) The absence of indicators of excessive erosion such as rills, soil pedestals, and actively eroding gullies.

c) The appropriate amount, type, and distribution of vegetation reflecting the presence of the Desired Plant Community [DPC], where identified in a land use plan, or where the DPC is not identified, a community that equally sustains the desired level of productivity and properly functioning ecological conditions.

B. Standard 2. Riparian and wetland areas are in properly functioning condition. Stream channel morphology and functions are appropriate to soil type, climate and landform.

As indicated by:

a) Streambank vegetation consisting of, or showing a trend toward, species with root masses capable of withstanding high streamflow events. Vegetative cover adequate to protect stream banks and dissipate streamflow energy associated with high- water flows, protect against accelerated erosion, capture sediment, and provide for groundwater recharge.

b) Vegetation reflecting: Desired Plant Community, maintenance of riparian and wetland soil moisture characteristics, diverse age structure and composition, high vigor, large woody debris when site potential allows, and providing food, cover and other habitat needs for dependent animal species.

c) Revegetating point bars; lateral stream movement associated with natural sinuosity; channel width, depth, pool frequency and roughness appropriate to landscape position.

d) Active floodplain.

C. Standard 3. Desired species, including native, threatened, endangered, and special-status species, are maintained at a level appropriate for the site and species involved.

As indicated by:

a) Frequency, diversity, density, age classes, and productivity of desired native species necessary to ensure reproductive capability and survival.

b) Habitats connected at a level to enhance species survival.

c) Native species reoccupy habitat niches and voids caused by disturbances unless management objectives call for introduction or maintenance of nonnative species.

d) Appropriate amount, type, and distribution of vegetation reflecting the presence of (1) the Desired Plant Community [DPC], where identified in a land use plan conforming to these Standards, or (2) where the DPC is identified a community that equally sustains the desired level of productivity and properly functioning ecological processes.

D. Standard 4. BLM will apply and comply with water quality standards established by the State of Utah (R.317-2) and the Federal Clean Water and Safe Drinking Water Acts. Activities on BLM Lands will support the designated beneficial uses described in the Utah Water Quality Standards (R.317-2) for surface and groundwater. (1)

As indicated by:

a) Measurement of nutrient loads, total dissolved solids, chemical constituents, fecal coliform, water temperature and other water quality parameters.

b) Macro-invertebrate communities that indicate water quality meet aquatic objectives.

(1) BLM will continue to coordinate monitoring water quality activities with other Federal, State and technical agencies.

Utah Bureau of Land Management--Guidelines for Grazing Management

A. Grazing management practices will be implemented that:

a) Maintain sufficient residual vegetation and litter on both upland and riparian sites to protect the soil from wind and water erosion and support ecological functions;

b) Promote attainment or maintenance of proper functioning condition riparian/wetland areas, appropriate stream channel morphology, desired soil permeability and infiltration, and appropriate soil conditions and kinds and amounts of plants and animals to support the hydrologic cycle, nutrient cycle, and energy flow.

c) Meet the physiological requirements of desired plants and facilitate reproduction and maintenance of desired plants to the extent natural conditions allow;

d) Maintain viable and diverse populations of plants and animals appropriate for the site;

e) Provide or improve, within the limits of site potentials, habitat for Threatened or Endangered Species;

f) Avoid grazing management conflicts with other species that have the potential of becoming protected or special status species;

g) Encourage innovation, experimentation and the ultimate development of alternatives to improve rangeland management practices;

h) Give priority to rangeland improvement projects and land treatments that offer the best opportunity for achieving the Standards.

B. 2. Any spring or seep developments will be designed and constructed to protect ecological process and functions and improve livestock, wild horse and wildlife distribution.

C. New rangeland projects for grazing will be constructed in a manner consistent with the Standards. Considering economic circumstances and site limitations, existing rangeland projects and facilities that conflict with the achievement or maintenance of the Standards will be relocated and/or modified.

D. Livestock salt blocks and other nutritional supplements will be located away from riparian/wetland areas or other permanently located, or other natural water sources. It is recommended that the locations of these supplements be moved every year.

E. The use and perpetuation of native species will be emphasized. However, when restoring or rehabilitating disturbed or degraded rangelands non-intrusive, nonnative plant species are appropriate for use where native species (a) are not available, (b) are not economically feasible, can not achieve ecological objectives as well as nonnative species, and/or (d) cannot compete with already established native species.

F. When rangeland manipulations are necessary, the best management practices, including biological processes, fire and intensive grazing, will be utilized prior to the use of chemical or mechanical manipulations.

G. When establishing grazing practices and rangeland improvements, the quality of the outdoor recreation experience is to be considered. Aesthetic and scenic values, water, campsites and opportunities for solitude are among those considerations.

H. Feeding of hay and other harvested forage (which does not refer to miscellaneous salt, protein, and other supplements) for the purpose of substituting for inadequate natural forage will not be conducted on BLM lands other than in (a) emergency situations where no other resource exists and animal survival is in jeopardy, or (b) situations where the Authorized Officer determines such a practice will assist in meeting a Standard or attaining a management objective.

I. In order to eliminate, minimize, or limit the spread of noxious weeds, (a) only hay cubes, hay pellets, or certified weed-free hay will be fed on BLM lands, and (b) reasonable adjustments in grazing methods, methods of transport, and animal husbandry practices will be applied.

J. To avoid contamination of water sources and inadvertent damage to non-target species, aerial application of pesticides will not be allowed within 100 feet of a riparian/wetland area unless the product is registered for such use by the EPA.

K. On rangelands where a standard is not being met, and conditions are moving toward meeting the standard, grazing may be allowed to continue. On lands where a standard is not being met, conditions are not improving toward meeting the standard or other management objectives, and livestock grazing is deemed responsible, administrative action with regard to livestock will be taken by the Authorized Officer pursuant to CFR 4180.2(c).

L. Where it can be determined that more than one kind of grazing animal is responsible for failure to achieve a Standard, and adjustments in management are required, those adjustments will be made to each kind of animal, based on interagency cooperation as needed, in proportion to their degree of responsibility.

M. Rangelands that have been burned, reseeded or otherwise treated to alter vegetative composition will be closed to livestock grazing as follows: (1) burned rangelands, whether by wildfire or prescribed burning, will be ungrazed for a minimum of one complete growing season following the burn; and (2) rangelands that have been reseeded or otherwise chemically or mechanically treated will be ungrazed for a minimum of two complete growing seasons.

N. Conversions in kind of livestock (such as from sheep to cattle) will be analyzed in light of Rangeland Health Standards. Where such conversions are not adverse to achieving a Standard, or they are not in conflict with BLM land use plans, the conversion will be allowed.

Appendix E

Strategies for Management—Tools for Assessment of Condition and Management Options

1. Standardized Precipitation Index (http://www.wrcc.dri.edu/cgi-bin/spiFmap.pl?spi72) as a way of measuring drought that is different from the Palmer drought index (PDSI). Like the PDSI, this index is negative for drought, and positive for wet conditions. But the SPI is a probability index that considers only precipitation, while Palmer's indices are water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff). The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive.

   The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater than median precipitation, while negative values indicate less than median precipitation. A drought event occurs any time the SPI is continuously negative and reaches an intensity where the SPI is –1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues. The accumulated magnitude of drought can also be drought magnitude, and it is the positive sum of the SPI for all the months within a drought event.

   Since the SPI is standardized, both drought and wet spell conditions can be represented for all climate types. This index also determines criteria for the

Standardized Precipitation Index Value	
2.0 or More	Extremely Wet
1.5 to 1.99	Very Wet
1.0 to 1.49	Moderately Wet
0.99 to –0.99	Near Normal
-1.0 to –1.49	Moderately Dry
2.0 or More	Extremely Wet
1.5 to 1.99	Very Wet

   duration of a drought or wet spell event for any time scale. For example, the beginning of a drought is anytime when the SPI value is negative for a continuous period of time and gets to be equal to/less than a value of –1.0. This event would then end whenever the value became positive. If you want to find the total magnitude of the drought event, all you need to do is take the absolute value of the sum of all SPI values for the months in which the event occurred.

There are some advantages to the SPI, one, which includes the fact that it is a much less complex index to determine than the Palmer Index. Another advantage is that is can provide early warnings of an on-coming drought and its possible severity. This early warning could give people and businesses time to prepare for the possible on-set of a long-term dry spell.

2. **Palmer Drought Severity Index.**
   (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/palmer.gif)

The Palmer is a soil moisture algorithm calibrated for relatively homogeneous regions. Government agencies and states rely on the Palmer to trigger drought relief programs. Palmer values may lag emerging droughts by several months; less well suited for mountainous land or areas of frequent climatic extremes; complex, has an unspecified, built-in time scale that can be misleading. The only type of precipitation taken into consideration is rain. Things such as snowfall or frozen ground, things that can affect the moisture content of the ground a great deal, are not looked at. In regions where snowfall is a significant source of moisture, this index may become inaccurate. It also depends on how much snowfall the region gets as to how inaccurate the index would be.

Palmer Drought Severity Index Values	
4.0 or More	Extremely Wet
3.0 to 3.99	Very Wet
2.0 to 2.99	Moderately Wet
1.0 to 1.99	Slightly Wet
0.5 to 0.99	Incipient Wet Spell
0.49 to -0.49	Near Normal
-0.5 to -0.99	Incipient Dry Spell
-1.0 to -1.99	Mild Drought
-2.0 to -2.99	Moderate Drought
-3.0 to -3.99	Severe Drought
-4.0 to -4.99	Extreme Drought

The PDSI is calculated based on precipitation and temperature data, as well as the local Available Water Content (AWC) of the soil. From the inputs, all the basic terms of the water balance equation can be determined, including evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer.

The palmer index is a very popular index that is typically calculated on a monthly basis, but weekly calculations (especially during the growing season) are also available. One reason the index is popular is due to the fact that it is the most effective in measuring impacts affected by soil conditions, such as agriculture. It is a good tool for monitoring droughts and is used to begin actions/plans dealing with areas affected by a significant drought. The palmer index also provides good opportunities to take current soil conditions and compare them to periods of drought/wet spell in the past.

It is most effective measuring impacts sensitive to soil moisture conditions. It has also been useful as a drought-monitoring tool and has been used to trigger actions associated with drought contingency plans. Positive characteristics of the Palmer Index that contribute to its popularity: (1) it provides decision makers with a measurement of the abnormality of recent weather for a region; (2) it provides an opportunity to place current conditions in historical perspective; and (3) it provides spatial and temporal representations of historical droughts.

2. **Percent of Normal Precipitation.**
(http://www.wcc.nrcs.usda.gov/water/snow/past_up2.pl?report=ut&year=2002&month=09&day=30) The Percent of Normal Precipitation is a simple calculation well suited to the needs of meteorologists and general audiences. It is quite effective for comparing a single region or season. The percent of normal precipitation is one of the simplest measurements of rainfall for a location. It is calculated by dividing actual precipitation by normal precipitation -- typically considered to be a 30-year mean -- and multiplying by 100%. This can be calculated for a variety of time scales. Normal precipitation for a specific location is considered to be 100%. One disadvantage of this index is the fact that it is easily misunderstood. This is a mathematically constructed value that doesn't always match up with what you would expect the weather to be. Another disadvantage is that the average precipitation is sometimes different than the median precipitation (meaning that it is a value exceeded by half of the precipitation events). Using this index is implying that the average and median values are the same, but monthly/seasonal scales of precipitation do not have normal distributions.

Mountain data from NRCS SNOTEL Sites provide percent of normal precipitation data for each of the water basins in Utah. In addition, regional weekly percent of normal precipitation maps are available on the Climate Prediction Center's website:
(www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/us_monthly_pct_precip.html)

3.**Climate Prediction Center's Drought Monitor Report**
(http://www.drought.unl.edu/dm/monitor.html)

On each Thursday, the CPC, together with the United States Department of Agriculture and the
National Drought Mitigation Center in Lincoln, Nebraska, issues a weekly drought assessment
called the United States Drought Monitor. The Monitor provides a consolidated depiction of
national drought conditions based on a combination of drought indicators and field reports. The

Drought Monitor is intended to provide a general and up-to-date summary of current drought conditions across the 50 states, Puerto Rico, and the Pacific possessions. This national product is designed to provide the "big picture" so the general public, media, government officials, and others can see what is happening around the country. To keep the map from becoming too complex, the drought categories shown represent typical drought intensities, not every drought intensity, within the area. The map is not designed to depict local conditions or to replace drought warnings and watches issued by local or regional government entities.

D0-D4: The Drought Monitor summary map identifies general drought areas, labeling droughts by intensity, with D1 being the least intense and D4 being the most intense. D0, drought watch areas, are either drying out and possibly heading for drought, or are recovering from drought but not yet back to normal, suffering long-term impacts such as low reservoir levels. **A, W and F:** Since "drought" means a moisture deficit bad enough to have social, environmental or economic effects, a description of what the primary physical effects are generally included: **A** = agricultural effects, both crops and livestock; **W** = water supplies, rivers, groundwater and reservoirs; **F** = fire danger (wildfires)

Drought intensity categories are based on six key indicators and numerous supplementary indicators. The accompanying drought severity classification table shows the ranges for each indicator for each dryness level. Because the ranges of the various indicators often don't coincide, the final drought category tends to be based on what the majority of the indicators show. The analysts producing the map also weight the indices according to how well they perform in various parts of the country and at different times of the year. Also, additional indicators are often needed in the West, where winter snowfall has a strong bearing on water supplies.

Drought Severity Classification								
		RANGES						
Category	Description	Possible Impacts	Palmer Drought Index	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Percent of Normal Precip	Standardized Precipitation Index (SPI)	Satellite Vegetation Health Index
D0	Abnormally Dry	Going into drought: short-term	-1.0 to -1.9	21-30	21-30	<75 % for 3	-0.5 to -0.7	36-45

		dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.				months		
D1	Moderate Drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested	-2.0 to -2.9	11-20	11-20	<70 % for 3 months	-0.8 to -1.2	26-35
D2	Severe Drought	Crop or pasture losses likely; fire risk very high; water shortages common:	-3.0 to -3.9	6-10	6-10	<65 % for 6 months	-1.3 to -1.5	16-25

		water restrictions imposed						
D3	Extreme Drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions	-4.0 to -4.9	3-5	3-5	<60 % for 6 months	-1.6 to -1.9	6-15
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies	-5.0 or less	0-2	0-2	<65 % for 12 months	-2.0 or less	1-5

4. **Biomass Stress Indices.** Modis (or Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the TERRA (EOS AM) and Aqua (EOS PM) satellites. Terra's orbit around the earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire earth's surface every 1 to 2 days (daily in the northern latitudes), acquiring data in 36 co-registered spectral bands, or groups of wavelengths at moderate spatial resolutions of 250, 500, and 1000 meters.

The bands used are 250-meter resolution. Indices are an indicator of the loss of biomass. To identify the areas of biomass stress, MODIS band 1 (visible red) and band 2 (infra red) are used in the equation **2/infra red. Stress indices values (5 ranges of color sets in each value, varying from dark green to dark red) of low, moderate, high, very high, and extreme are determined and mapped.

During 2002, satellite data was compiled at the USDA Forest Service (USFS) Remote Sensing Applications Center in cooperation with NASA Goddard Space Flight Center, and the University of Maryland. Region 4 USDA Forest Service then did biomass stress processing. Imagery was collected by the Moderate Resolution Imaging Spectroradiometer (MODIS). Future availability of this drought-monitoring index is contingent upon USFS funding and staffing.

5. **Vegetation Health Index.** Since drought covers large areas, it is difficult to monitor them using conventional systems. In recent years, the National Oceanic and Atmospheric Administration (NOAA) has designed a new Advanced Very High Resolution Radiometer (AVHRR) based Vegetation Condition Index (VCI) and Temperature Condition Index (TCI), which have been useful in detecting and monitoring large-area drought-related vegetation stress. Vegetation is monitored from NOAA operational polar-orbiting satellites. The VCI and TCI are used to determine the water and temperature related vegetation stress occurring during drought.

The images are color-coded maps of vegetation condition (health) estimated by the Vegetation and Temperature Condition Index (VT). The VT is a numerical index, which changes from 0 to 100 characterizing change in vegetation conditions from extremely poor (0) to excellent (100). Fair conditions are coded by green color (50), which changes to brown and red when conditions deteriorate and to blue when they improve. The VT reflects indirectly a combination of chlorophyll and moisture content in the vegetation and also changes in thermal conditions at the surface. This new approach combines the visible, near infrared, and thermal radiances in a numerical index characterizing vegetation health. This approach is extremely useful in detecting and monitoring such complex and difficult-to-identify phenomenon as drought. The VT values below 35 are used for identifying vegetation stress, which is an indirect drought indicator. The VT is very useful for early drought detection, assessing drought area coverage, duration, and intensity, and for monitoring drought impacts on vegetation and agricultural crops.

Maps can be downloaded from NOAA/NESDIS (National Environmental Satellite Data and Information Service) website at http://orbit-net.nesdis.noaa.gov/crad/sat/surf/vci/usavhcd.html.
Maps are colored depicting levels of stress using a band of nine colors indicating stress, fair, or favorable conditions.

7. **Visual Greenness.** NOAA (National Climatic Data Center, Department of Commerce). Over the last 10 years a team from NOAA has been developing techniques and algorithms that process microwave imagery from the Special Sensor Microwave Imager into climate products that assess surface wetness, temperature, and snow cover around the world. This data set is unique and provides valuable insights on growing conditions around the world in near real time. Furthermore, since microwave emission penetrates through clouds, the satellite can observe surface conditions when Infrared and visible imagery are unavailable. In addition, they have based all the data on a 14-year base period, in order to allow the user to easily interpret the significance of the current conditions (relative to the previous years).

Vegetation Greenness Maps are derived weekly from Normalized Difference Vegetation Index (NDVI) data observed by satellites and provided by the EROS Data Center, U.S.

Geological Survey and the USDA Forest Service, Intermountain Research Station. These maps have a 1.1-kilometer (.6 mile) spatial resolution.

Visual Greenness (VG) - Indicates how green each pixel is in relation to a standard reference such as a highly green and densely vegetated agricultural field. An image is produced that portrays **vegetation greenness, as you would expect to see** if you were flying over the landscape. In this context, normally dry areas will look cured compared to fully vegetated areas.

Maps can be downloaded from www.agribiz.com/weather/visual.html. Maps are colored depicting levels of greenness (water content) using 11 colors ranging from deep red to blue in 10% increments, with 1-10% being deep red and over 100% being water.

Extension Service

OREGON STATE UNIVERSITY

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THE GRAZIER

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COMING EVENTS

Listen to the Ripples: Working Together for Watershed Communities. Nov. 20-23, 2002, Deschutes County Fair and Expo Center, Redmond, OR. Joint Conference, 7th Biennial Oregon Watershed Enhancement Board and 53rd Annual Meeting Oregon Association of Conservation Districts. The program is described as broadly designed for soil and water conservation districts, watershed councils, federal and state agencies, landowners, academics, local officials, and others interested in their local natural resources. Register online at: www.oweb.state.or.us

Cows and Creeks Symposium Dec. 13, 2002, Meadow Lakes Golf Course, Prineville, OR. Speakers include Dr. Mike Borman (Rangeland Resources Extension Specialist, Dept. of Rangeland Resources, OSU) with an introduction on watershed considerations and a discussion of research results and implications from a water temperature research project in the Burnt River system; Dr. Rob Atwill (Univ. of California, Davis, Extension Veterinarian) speaking on "Livestock and Water Quality: How Do We Know That Livestock are the Problem?"; Dr. Larry Larson (Dept. of Rangeland Resources, OSU, and OSU Agriculture Program at Eastern Oregon University) speaking on the topic of "Nonuse and Changes in Riparian Areas"; Dr. Tim Delcurto (Eastern Oregon Agricultural Research Station, Union) on "Livestock Management and Behavior in Riparian Areas"; and Dr. Derek Bailey (Montana State University, Havre Research Station) on "Livestock Management and Behavior in Uplands." Registration includes lunch and handouts. Early registration by Dec. 2 is $10. Later registration is $15. The symposium is sponsored by the Crook County Extension Office and Crook County Soil & Water Conservation District with program support by Oregon Watershed Enhancement Board. For registration and program information, contact Tim Deboodt or Cory Parsons at 541-447-6228.

Society for Range Management 56th Annual Meeting. Feb. 1-7, 2003, Casper, WY. Meeting theme is "Rangelands – Diversity Through Time," and the primary focus of the technical sessions and symposia will be rangeland ecology, and multiple values associated with rangeland ecosystems. Currently planned sessions will be arranged around the following topics: Rangeland Ecology: Fire Ecology, Riparian Ecology, Drivers in Rangeland Ecosystems, Rangeland Bird Ecology, Endangered Species, Nutrient Dynamics; Rangeland Economics and Sociology: Conservation Easements and Grass Banks, Cooperative Management; Plant/Animal Relationships: Animal Behavior, Plant/Animal Interactions; Rangeland Management: Invasive Species, History – Pleistocene to Present, Interspecies Dynamics; Technology and Management: Rapid Assessment Techniques, GIS and Remote Sensing. Graduate Student competitions will be held for both papers and posters for both Ph.D. and M.S. students. Program and registration information is available on the SRM homepage at: http://www.rangelands.org

Second Annual Northwest Stream Restoration Design Symposium. Feb. 4-7, 2003, Skamania Lodge, Stevenson, WA. The symposium provides a forum for stream restoration professionals to exchange ideas and compare lessons learned. The preliminary program is on the conference website: http://rrnw.org/Skamania2003/

Livestock Management for Fisheries Habitat: A collaborative approach. April 29-30, 2003, Prineville, OR. This workshop is intended to bring together fisheries biologists and rangeland managers to present fisheries and livestock needs, and management strategies that will provide habitat for both. The workshop is being jointly hosted by the Pacific Northwest Section, Society for Range Management and the Oregon Chapter, American Fisheries Society. Program details and registration information will be in the Piscatorial Press and the PNW Section SRM newsletter. The next *Grazier* will have additional information as well.

GRAZING MANAGEMENT GUIDELINES

(**Editor's Note**: Editor's Note: This is the (late) first issue of *The Grazier* for the 2002-03 academic year. I thought it might be useful to revisit some basics of range and pasture management. The following information was prepared by Kevin Guinn, Area Range Conservationist, Natural Resource Conservation Service, Ephrata, WA. It has been through technical review by Gerald Rouse (State Range Management Specialist, NRCS, Spokane, WA) and Dr. David Briske, Professor of Ecophysiology, Dept. of Rangeland Ecology and Management, Texas A&M University. I have modified the format to save space and I have edited a bit, but not much. Keep in mind that some of the numbers presented are generic. They represent rule-of-thumb guidelines if specific responses by specific grasses under specific conditions are not known.

- There is no such thing as Range Readiness for plants.
- The Critical Period is not early spring.
- Regrowth does not come from root carbohydrates. It does come from current photosynthate produced by existing leaf area.

I. Effects of Grazing

Every function of a plant is affected by grazing:
- Size of food factory (photosynthetic leaf area).
- Food Production.
- Root Growth.
- Water and nutrient availability.
- Carbohydrate storage in shoots.

The effect of grazing is dependent upon:
- Season of use and growth stage.
- Grazing intensity (remaining leaf area), which directly affects light interception.
- Frequency of grazing (regrowth grazed).
- Type of plant (warm season vs. cool season; forb, shrub, vs. grass).
- Availability of growing points and new tiller buds.
- Shoot carbohydrate reserves.
- Size of root system.
- Physical effects of grazing animals on plants and soil (trampling may be negative but nutrient cycling a positive response).

How grazing at different times of the year affects grasses:
(Note: The dates below are from Ephrata, WA at 1500 feet; Table 1).

▶When grazing is relatively low risk: Summer 6/26-8/30, Fall 9/1-11/30, Winter 12/1-2/28
* Grazing has little effect on plant growth unless grazing is severe.
* The reduction of tillers under heavy grazing is due to higher over-winter mortality rather than an inadequate number of tillers emerging in the fall.
* *Fall green up is not free forage!* It is the basis for next year's production.
* Cured vegetation protects new tillers.
* Cured vegetation provides energy and green growth provides protein to animals.
* Wolf plants are not as likely to be avoided during this period.

▶When grazing is somewhat higher risk: Early Spring 3/1-4/15
* Has little effect as long as no more than 50% of current growth is removed and duration and frequency are controlled.
* Plants are set for vegetative growth and able to rapidly replace lost leaves and stems, if growing conditions are favorable.

* Growing points are not elevated, and thus, protected.

Myth #1: Grazing after range readiness is best for bunchgrasses. This is WRONG! The range readiness concept is outdated.

* All you need is the soil to be firm enough to prevent soil compaction and enough growth for the livestock.
* Consider the effect of leaf area and air temperature on growth rate and the likelihood of the forage supply staying ahead of the livestock.
* You need enough old growth and magnesium blocks to avoid grass tetany.

►When grazing is highest risk (CRITICAL PERIOD): Late Spring 3/20-6/25
* The growing points are elevated, and thus, vulnerable.
* If growing points are removed, replacement tillers must come from axillary buds.
* Plants are committed to seed production.
* The ability to replace lost leaves and stems is low and declining.

Myth #2: The critical period is early spring. This is WRONG!
The critical period is when plants are trying to make seed (boot stage through soft dough stage).

* At Ephrata, WA from 1988-1994, the critical period came between 3/20 and 6/25. See the chart "Comparing the Years."
* Grazing annually during the critical period can have a severe impact and even kill bunchgrasses.

The effects of grazing depends upon what's removed.
- Leaf blades only- minimal if growing conditions are good.
- Leaf sheaths- regrowth will be delayed.
- Apical meristem- tiller will die; must be replaced by activation of an axillary bud.

How grazing affects roots: *(Numbers are based on a USDA report by Crider in 1955 in a greenhouse clipping study. Actual grazing may have different results.)*
- As long as no more than 50% of top-growth is removed, grazing has little effect on the roots.
- At 60% use, HALF of the roots stop growing for 12 days.
- At 80% use, ALL of the roots stop growing for 12 days.
- At 90% use, ALL of the roots stop growing for 18 days.
    - The growing season at Ephrata is 90-140 days (K. Guinn study). 12-18 days relates to 10-20% of the growing season when the plants are not producing.
    - Under progressively heavier grazing, roots will have fewer branches; become sparser, shorter, and more concentrated in the top portion of the soil profile.
    - A balance between roots and top-growth will always occur.
    - To minimize weed invasion, have plants with a large, healthy root system.
    - This is why we should generally graze no more than 50% of the top-growth during the growing season.

How grazing affects plant growth.

- For sod-formers (non-jointed species):
  * Maintain leaves and growing points and the plant keeps producing.
  * Graze the leaf growing points and the plants are hurt.

- For bunchgrasses (jointed species):

  * As seedheads are elevated on the stem, they become vulnerable to removal.
  * Graze the growing points of stems, you not only kill the stems, but new growth must come from axillary buds which reduces next year's stems, and
  * Less than a 1:1 ratio of stem replacement for next year may reduce the stand.

Where does regrowth come from?

Myth #3: Root carbohydrate reserve is most important for regrowth following a severe grazing. This is WRONG!

- There is no indication that root carbohydrate reserves are mobilized for shoot growth.
- Most reserves are located in stem bases.
- Reserves in grass stem bases affect regrowth for only 2-7 days following grazing.

- Current photosynthesis is the most significant source of carbohydrates (88-99%).
- Severe grazing cannot be expected to increase production of native bunchgrasses, especially in dry environments.

- Bunchgrasses may be eliminated by intensive, long-term grazing.
- Decrease of basal areas of individual plants.
- Fragmentation of large plants into smaller plants.
- Plant basal areas are reduced below critical size and tiller numbers are reduced.

- Characteristics that provide resistance to grazing:
- Low growing points.
- Delayed elevation of growing points.
- Predominance of vegetative shoots over reproductive shoots.
- Deep and expansive root system or added drought tolerance and acquisition of minerals.

II. Grazing Management Guidelines

There are three types of grasses:
Match the type of grass with its appropriate grazing management strategy.

1. Non-jointed species (sod-formers).
2. Introduced jointed species (bunchgrasses).
3. Native jointed species (bunchgrasses).

Four criteria determine the susceptibility to grazing and the rate of recovery.

1. The amount of leaves and stems remaining after defoliation.
2. The susceptibility of growing point to damage or removal:
   * Growth form (bunch or sod-former).
   * Ratio of reproductive to vegetative tillers.
   * Height and location of growing point (time of year).
   * Time of grazing.
3. Ability of plants to produce new tillers.
4. Ability of plants to allocate resources to maintain a favorable shoot-root ratio.

Recovery by sod-formers (answers relate to four criteria above):
- Rancher decision to control intensity, duration, and timing of grazing.
- Growing points are protected.
- Easily produces new tillers.
- No problem with shoot-root ratio.

Recovery by bunchgrasses (answers relate to four criteria above):
- Rancher decision to control intensity, duration, and timing of grazing.
- Growing points can be vulnerable depending on growth stage.
- Ability to produce new tillers is quite limited.
- Maintenance of shoot-root ratio is variable among grass species.
  * The response difference between sod-formers and bunchgrasses is why they have different grazing management guidelines based on different amounts of biomass removed and/or remaining on these two growth forms.

Maintaining shoot-root ratio following defoliation.

- Crested Wheatgrass
  * Introduced from Asia; evolved with heavy grazing pressure.
  * Reduces root growth after defoliation.
  * Allocates more resources to shoot growth.
  * Quickly re-establishes a favorable root-shoot ratio.

- Bluebunch Wheatgrass
  * Native; evolved without *heavy* grazing pressure.
  * Roots grow at the same rate after defoliation.
  * Unable to re-allocate resources to grow additional leaves and stems.
  * Ratio between shoot and roots becomes very unbalanced.
  * In subsequent years:
    -Excessive root die off
    -Poor plant health
    -Plant death
  * The response difference between crested and bluebunch is why natives and introduced species have different grazing management guidelines. The response difference is related to rapid new tiller production in crested.

Management guidelines for non-jointed species:

Kentucky bluegrass	Regar brome
tall fescue	orchardgrass
pinegrass	perennial ryegrass
quackgrass	saltgrass (not a true sodformer)

* High number of vegetative to reproductive stems.
* Growing points remain close to the ground, usually too low to be grazed.
* Able to quickly regrow if growing points have not been removed.
* If growing points are removed, they can readily activate other growing points.
* Has ability to replace photosynthetic tissue quickly when soil moisture exists.

- Leave enough leaves and stems to keep plants producing.
    * Graze above apical meristems and growing points.
- Leave enough leaves and stems for site stability.
    * Two inches for site protection.
    * Cattle need four inches to effectively graze.
- Grazing systems that are appropriate.
  (1) Continuous but moderate use.
  (2) Rapid rotation started early to keep plants vegetative with a 21-25 day regrowth period for each rapid growth.
      -Short duration.
      -Savory grazing method.
  (3) Deferred rotation and rest rotation are overkill.
  (4) The key area is the heavily used area of the pasture.

Management guidelines for introduced jointed species:

smooth brome	reed canarygrass
creeping meadow foxtail	annual ryegrass
pubescent wheatgrass	crested wheatgrass
intermediate wheatgrass	timothy
Siberian wheatgrass	tall wheatgrass

- If growing point is not removed:
    * Reduces root growth after defoliation.
    * Allocates more resources to shoot growth.
    * Quickly re-establishes a favorable root-shoot ratio.

- Ability to regrow depends on the state of growth and the ability to reallocate resources:
    * For introduced species, if growing point is removed during the boot stage, the reallocation of energy goes to axillary buds for tiller recruitment, but moisture will most likely be limiting.
- Removal of topgrowth at or after soft dough stage results in plants going dormant.
    * Proper grazing use:
      - 50% of what there is during the growing season.
      - 60% when dormant.
    * Graze no field more than half the growing season.
    * Graze no field more than 2 out of 3 years during the critical period (boot through soft dough stage).
    * Grazing systems that are appropriate:
      (1) Rotation of grazing between critical and noncritical periods from one year to the next.
      (2) Deferred rotation, rest rotation and intensive deferred rotation are overkill.
      (3) Key area should reflect average use.

Management guidelines for native bunchgrasses (jointed species):

bluebunch wheatgrass	needle-and-thread
Idaho fescue	Thurber needlegrass
basin wildrye	big bluegrass
prairie Junegrass	

- If growing point is not removed.
    * Roots grow at the same rate after defoliation.
    * Unable to re-allocate resources to grow additional leaves and stems.
    * Ratio between shoot and roots becomes very unbalanced.

- Ability to regrow depends on the stage of growth and the ability to reallocate resources.
    * For native species, if growing point is removed during the boot stage, the reallocation of energy goes to roots; this throws the root:shoot ratio off resulting in a long term die-off of a portion of the plant.

- Removal of top-growth at or after soft dough stage results in plants going dormant.
    * Proper grazing use:
      - 50% of what there is during the growing season.
      - 60% when dormant.
    * Graze no field more than half the growing season.
    * Graze no field more than 1 out of 3 years during the critical period (boot through soft dough stage).
    * Defer each field 1 out of 3 years (growing season).

* Grazing systems that are appropriate:
  (1) Deferred rotation.
  (2) Rest rotation.
  (3) Intensive deferred rotation.
  (4) Short duration and Savory grazing method are not appropriate.
  (5) Rotation of grazing between critical and non-critical periods from one year to the next when key areas are the heavily used areas of the pasture.

Management guidelines for forest grazing:
- If all grasses are native bunchgrasses, use the criteria above for native bunchgrasses.
- **If all grasses are non-jointed species (pinegrass, bluegrass), use the criteria above for sod-formers.**
- If the area has both sod-formers and native bunchgrasses:
  * Fence separately and use separate criteria for each, or
  * If cannot separate, use the criteria for native bunchgrasses.

Management guidelines for riparian areas:
- Fence out (at least until vegetation response is sufficient) when:
  * Banks are not stable.
  * Sediment is not being filtered.
  * Riparian area is large enough to create a riparian pasture.
- Managing woody species:
  * If being suppressed, install a temporary fence to jumpstart the plants.
  * Defer summer and fall.
  * Graze after spring runoff and let plants regrow for the next runoff event.
- Managing grasses and grass-like species:
  * If grasses in riparian areas are sod-formers, use sod-formers criteria tempered with the woody criteria above.
  * Most sedges will respond positively to management based on native bunchgrass criteria.

Management Guidelines for Annual Rangeland:
- In the rare cases where the plant communities are 100% annuals:
  * Graze so as to leave enough plant cover to protect the site from erosion (at least 30% cover).
  * Monitor trend (Range Health Indicator Worksheet is a useful tool).
- When the plant community still has perennials present:
  * Manage for the perennials.
  * Graze early spring and fall:
    (1) In early spring, move the livestock when they switch their diet from annuals to perennials.
    (2) In the fall, graze no more than 60% of the perennial bunchgrasses; maintain a stubble height so that 40% of the bunchgrasses are not eaten.

Conclusions on Grazing Management.
- Only two factors of plant growth are within our control:
  (1) Leaf area remaining after grazing. (Intensity)
  (2) Time of grazing. (Timing and Duration)
- Leaf area remaining after grazing and time of grazing should be the primary focus of ranchers' management.
- A cow is a management tool to manipulate and improve plant communities.
- Do not forget the two natural laws:
  (1) If we keep down the shoot, we kill the root.
  (2) Nature abhors empty space; abuse the good plants and undesirables will invade.
- Over-grazed grasses cannot remain healthy, vigorous, and productive any more than a steer can gain weight on a maintenance ration.
- Leave enough leaf area to ensure photosynthesis.
- For native bunchgrasses minimize the severity of grazing when grasses are more susceptible by:
  * Grazing no field more than half the growing season.
  * Grazing only 1 in 3 years during the critical period (2 out of 3 for introduced jointed).
  * Deferring each field 1 out of every 3 years during the growing season.

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TABLE 1

PLANT PHENOLOGY
For
Bluebunch Wheatgrass

Ephrata, Washington
1500' Elevation

K. Guinn 1/94

GROWTH STAGE	1988	1989	1990	1991	1992	1993	1994	7-yr. Ave
7-8" Leaves	3/20	4/02	3/22	3/28	3/01	4/11	3/20	3/24
Boot	4/18	4/18	4/10	4/21	3/25	4/25	4/10	4/14
Seedheads Out	5/10	5/04	4/22	5/01	4/12	5/16	5/01	5/01
Anthesis	5/30	5/25	5/06	5/20	5/10	5/23	5/14	5/18
			5/27	6/02				
End Soft Dough	6/10	6/11	*6/01	*6/23	5/31	6/05		6/10
Seed Shatter	6/19	6/25	N/A	6/30	6/07	6/27		6/20
Critical Period								
	4/15	4/15	4/05	4/20	3/20	4/20	4/10	4/10
	6/15	6/15	6/05	6/25	6/05	6/20		6/15
Number Days	61	61	61	66	78	61		65
End of Deferment Period:								
	6/15	6/15	6/05	6/25	6/05	6/20		6/15

*No seed formation in 1990.

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TECHNICAL NOTES

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

RANGE 34

Spokane, Washington
August 1994

GRAZING MANAGEMENT GUIDELINES

by

Kevin Guinn
Area Range Conservationist
Soil Conservation Service
Ephrata, Washington

TECHNICAL REVIEW

by

Gerald B. Rouse
State Range Management Specialist
Soil Conservation Service
Spokane, Washington

and

Dr. Briske, Professor
Texas A and M
College Station, Texas

- THERE IS NO SUCH THING AS RANGE READINESS FOR PLANTS.
- THE CRITICAL PERIOD IS NOT EARLY SPRING.
- REGROWTH DOES NOT COME FROM ROOT CARBOHYDRATES; BUT, DOES COME FROM CURRENT PHOTOSYNTHATE OF EXISTING LEAF AREA.

A. Effects of Grazing

1. Every function of plants is affected by grazing:

   a. Size of food factory (photosynthetic leaf area).
   b. Food Production.
   c. Root growth.
   d. Water and nutrient availability.
   e. Carbohydrate storage in shoots.

2. The effect of grazing is dependent upon:

   a. Season of use and growth stage.
   b. Grazing intensity (remaining leaf area) which directly affects light interception.
   c. Frequency of grazing (regrowth grazed).
   d. Type of plant (warm season vs. cool season; forb, shrub, vs. grass).
   e. Availability of growing points and new tiller buds.
   f. Shoot carbohydrate reserves.
   g. Size of root system.
   h. Physical effects of grazing animals on plants and soil (trampling may be negative but nutrient cycling a positive response).

3. How grazing at different times of the year affects grasses.

(Note: The dates below are from Ephrata at 1500 feet; Table 1.)

a. When grazing is low risk:

Summer 6/16 - 8/30 Fall 9/1 - 11/30 Winter 12/1 - 2/28

* Grazing has little effect on plant growth unless grazing is severe.
* The reduction of tillers under heavy grazing is due to higher overwinter mortality rather than an inadequate number of tillers emerging in the fall.
* Fall green up is not free forage! It is the basis for next year's production.
* Cured vegetation protects new tillers.
* Cured vegetation provides energy and green growth provides protein to animals.
* Wolf plants are not as likely to be avoided during this period.

b. When grazing is high risk:

Early Spring 3/1 - 4/15

* Has little effect as long as no more than 50% of current growth is removed and duration and frequency is controlled.
* Plants are set for vegetative growth and able to rapidly replace lost leaves and stems, if growing conditions are favorable.
* Growing points are not elevated, and thus, protected.

* **Myth #1: Grazing after range readiness is best for bunchgrasses. This is WRONG! The range readiness concept is outdated.**

* All you need is the soil to be firm enough to prevent soil compaction and enough growth for the livestock.
* Consider the effect of leaf area and air temperature on growth rate and the likelihood of the forage supply staying ahead of the livestock.
* You need enough old growth and magnesium blocks to avoid grass tetany.

c. When grazing is very high risk (CRITICAL PERIOD):

Late Spring 3/20 - 6/25

* The growing points are elevated, and thus, vulnerable.
* If growing points are removed, replacement tillers must come from axillary buds.
* Plants are committed to seed production.
* The ability to replace lost leaves and stems is low and declining.

* **Myth #2: The critical period is early spring. This is WRONG!**

* **The critical period is when plants are trying to make seed (boot stage through soft dough stage).**

* At Ephrata, Washington from 1988 - 1994, the critical period came between 3/20 and 6/25. See the chart "Comparing the Years."
* Grazing during the critical period can have a severe impact and even kill bunchgrasses.

4. The effects of grazing depends upon what's removed.

   a. Leaf blades only - minimal if growing conditions are good.
   b. Leaf sheaths - regrowth will be delayed.
   c. Apical meristem-tiller will die; must be replaced by activation of an axillary bud.

5. How grazing affects roots (Figures 1 and 2):

   (Data a.-d. is from "Grass: The Stockman's Crop" which reports on a comprehensive test for different grasses.)

   a. As long as no more than 50% of topgrowth is removed, grazing has little effect on the roots.
   b. At 60% use, HALF of the roots stop growing for 12 days.
   c. At 80% use, ALL of the roots stop growing for 12 days.
   d. At 90% use, ALL of the roots stop growing for 18 days.
   e. The growing season at Ephrata is 90-140 days (K. Guinn study). 12-18 days relates to 10-20% of the growing season when the plants are not producing.
   f. Under progressively heavier grazing, roots will have fewer branches; become, sparser, shorter, and more concentrated in the top portion of the soil profile.
   g. A balance between roots and topgrowth will always occur.
   h. To minimize weed invasion, have plants with a large, healthy root system.
   i. This is why we should graze no more than 50% of the topgrowth during the growing season.

6. How grazing affects plant growth.

   a. For sodformers (non-jointed species):

      - Maintain leaves and growing points and the plant keeps producing.
      - Graze the leaf growing points and the plants are hurt.

   b. For bunchgrasses (jointed species):

      - As seedheads are elevated on the stem, they become vulnerable to removal.
      - Graze the growing points of stems, you not only kill the stems, but
      - New growth must come from axillary buds which reduces next years stems, and
      - Less than a 1:1 ratio of stem replacement for next year may reduce the stand.

7. Where does regrowth come from?

   a. **Myth #3: Root carbohydrate reserves is most important for regrowth following a severe grazing. This is WRONG!**

   b. There is no indication that root carbohydrate reserves are mobilized for shoot growth.
   c. Most reserves are located in stem bases.
   d. Reserves in grass stem bases affect regrowth for only 2-7 days following grazing.
   e. Current photosynthesis is the most significant source of carbohydrates (88-99%) (Figure 3).

8. Severe grazing cannot be expected to increase production of native bunchgrasses especially in dry environments.

9. Bunchgrasses may be eliminated by intensive, long-term grazing.

   a. Decrease of basal areas of individual plants.
   b. Fragmentation of large plants into smaller plants.
   c. Plant basal areas are reduced below critical size and tiller numbers are reduced.

10. Characteristics that provide resistance to grazing:

   a. Low growing points.
   b. Delayed elevation of growing points.
   c. Predominance of vegetative only shoots over reproductive shoots.
   d. Deep and expansive root system or added drought tolerance and acquisition of minerals.

B. Grazing Management Guidelines

1. There are three types of grasses:

   a. Non-jointed species (sodformers).
   b. Introduced jointed species (bunchgrasses).
   c. Native jointed species (bunchgrasses).
   d. Match the type of grass with its appropriate grazing management strategy.

2. Four criteria determine the susceptibility to grazing and the rate of recovery:

   a. The amount of leaves and stems remaining after defoliation.
   b. The susceptibility of growing point to damage or removal:

      * Growth form (bunch or sodformer).
      * Ratio of reproductive to vegetative tillers.
      * Height and location of growing point (time of year).
      * Time of grazing.

   c. Ability of plants to produce new tillers.
   d. Ability of plants to allocate resources to maintain a favorable shoot-root ratio.

3. Recovery by sodformers (answers relate to 2. a-d):

   a. Rancher decision to control intensity, duration, and timing of grazing.
   b. Growing points are protected.
   c. Easily produces new tillers.
   d. No problem with shoot-root ratio.

4. Recovery by bunchgrasses (Answers relate to 2. a-d):

   a. Rancher decision to control intensity, duration, and timing of grazing.
   b. Growing points are vulnerable depending on growth stage.
   c. Ability to produce new tillers is quite limited.
   d. Maintenance of shoot-root ratio is variable among grass species.

   * The response difference between sodformers and bunchgrasses is why they have different grazing management guidelines based on different amounts of biomass removed and/or remaining on these two growth forms.

5. Maintaining shoot-root ratio following defoliation:

   a. Crested Wheatgrass

      * Introduced from Asia; evolved with heavy grazing pressure.
      * Reduces root growth after defoliation.
      * Allocates more resources to shoot growth.
      * Quickly re-establishes a favorable shoot-root ratio.

   b. Bluebunch Wheatgrass

      * Native (Washington state grass); evolved without heavy grazing pressure.
      * Roots grow at the same rate after defoliation.
      * Unable to re-allocate resources to grow additional leaves and stems.
      * Ratio between shoot and roots becomes very unbalanced.
      * In subsequent years:

         - Excessive root die off
         - Poor plant health
         - Plant death

      * The response difference between crested and bluebunch is why natives and introduced species have different grazing management guidelines. The response difference is related to rapid new tiller production in crested.

6. Management guidelines for non-jointed species:

Kentucky bluegrass	Regar brome
tall fescue	orchardgrass
pinegrass	perennial ryegrass
saltgrass (not a true sodformer)	quackgrass

   * High number of vegetative to reproductive stems.
   * Growing points remain close to the ground, usually too low to be grazed.
   * Able to quickly regrow if growing points have not been removed.
   * If growing points are removed, they can readily activate other growing points.
   * Has ability to replace photosynthetic tissue quickly when soil moisture exists.

a. Leave enough leaves and stems to keep plants producing.

* Graze above apical meristems and growing points.

b. Leave enough leaves and stems for site stability.

* Two inches for site protection.
* Cattle need four inches to effectively graze.

c. Grazing systems that are appropriate:

(1) Continuous but moderate use.
(2) Rapid rotation started early to keep plants vegetative with a 21-25 day regrowth period for each field during rapid growth.

- Short duration.
- Savory grazing method.

(3) Deferred rotation and rest rotation are overkill.
(4) The key area is the heavily used area of the pasture.

7. Management guidelines for introduced jointed species:

smooth brome
creeping meadow foxtail
timothy
intermediate wheatgrass
Siberian wheatgrass
reed canarygrass
annual ryegrass
crested wheatgrass
pubescent wheatgrass
tall wheatgrass

* If growing point is not removed:

  * Reduces root growth after defoliation.
  * Allocates more resources to shoot growth.
  * Quickly re-establishes a favorable shoot-root ratio.

* Ability to regrow depends on the state of growth and the ability to reallocate resources:

  * For introduced species, if growing point is removed during the boot stage, the reallocation of energy goes to axillary buds for tiller recruitment, but moisture will most likely be limiting.

* Removal of topgrowth at or after soft dough stage results in plants going dormant.

a. Proper grazing use:

* 50% of what is there during the growing season.
* 60% when dormant.

b. Graze no field more than half the growing season.
c. Graze no field more than 2 out of 3 years during the critical period (boot through soft dough stage).

d. Grazing systems that are appropriate:

(1) Rotation of grazing between critical and noncritical periods from one year to the next.
(2) Deferred rotation, rest rotation and intensive deferred rotation are overkill.
(3) Key area should reflect average use.

8. Management guidelines for native bunchgrasses (jointed species):

bluebunch wheatgrass	needle-and-thread
Idaho fescue	Thurber needlegrass
basin wildrye	big bluegrass
prairie Junegrass	

* If growing point is not removed

  * Roots grow at the same rate after defoliation.
  * Unable to re-allocate resources to grow additional leaves and stems.
  * Ratio between shoot and roots becomes very unbalanced.

* Ability to regrow depends on the stage of growth and the ability to reallocate resources:

  * For native species, if growing point is removed during the boot stage, the reallocation of energy goes to roots; this throws the root:shoot ratio off resulting in a long term die-off of a portion of the plant.

* Removal of topgrowth at or after soft dough stage results in plants going dormant.

a. Proper grazing use:

  * 50% of what is there during the growing season.
  * 60% when dormant.

b. Graze no field more than half the growing season.
c. Graze no field more than 1 out of 3 years during the critical period (boot through soft dough stage).
d. Defer each field 1 out of 3 years (growing season).
c. Grazing systems that are appropriate:

(1) Deferred rotation.
(2) Rest rotation.
(3) Intensive deferred rotation.
(4) Short duration and Savory grazing method are <u>not appropriate</u>.
(5) Rotation of grazing between critical and non-critical periods from one year to the next when key areas are the heavily used areas of the pasture.

9. Management guidelines for forest grazing:

a. If all grasses are native bunchgrasses, use the criteria above for native bunchgrasses.

b. If all grasses are jointed species (pinegrass, bluegrass), use the criteria above for sodformers.

c. If the area has both sodformers and native bunchgrasses:

* Fence separately and use separate criteria for each, or
* If cannot separate, use the criteria for native bunchgrasses.

10. Management guidelines for riparian areas **(key areas are the non-functional components of the system):**

a. Fence out when:

* Banks are not stable.
* Sediment is not being filtered.
* Riparian area is large enough to create a riparian pasture.

b. Managing woody species:

* To establish rest 2 years or install a temporary fence.
* Defer summer and fall.
* Graze after spring runoff and let plants regrow for the next runoff event.

c. Managing grasses and grass-like species:

* If grasses in riparian areas are sodformers, so use sodformers criteria tempered with the woody criteria above.
* Most sedges will respond positively to management based on native bunchgrass criteria.

11. Management Guidelines for Annual Rangeland:

a. In the <u>rare cases</u> where the plant communities are 100% annuals:

* Graze so as to leave enough plant cover to protect the site from erosion (at least 30% cover).
* Use the Range Health Indicator Worksheet to judge trend.

b. When the plant community still has perennials present:

* Manage for the perennials.
* Graze early spring and fall:

(1) In early spring move the livestock when they switch their diet from annuals to perennials.

(2) In the fall graze no more than 60% of the perennials bunchgrasses; maintain a stubble height so that 40% of the bunchgrasses are not eaten.

12. Conclusions on Grazing Management:

a. Only two factors of plant growth are within our control:

* Size of leave area remaining after grazing. (Intensity)
* Time of grazing. (Timing and Duration)

b. The size of leave area remaining after grazing and time of grazing should be the primary focus of ranchers management.

c. A cow is a management tool to manipulate and improve plant communities.

d. Do not forget the two natural laws:

* If we keep down the shoot, we kill the root.
* Nature abhors empty space; abuse the good plants and undesirables will invade.

e. Over-grazed grasses cannot remain healthy, vigorous and productive any more than a steer can gain weight on a maintenance ration.

f. Leave enough leaf area to ensure photosynthesis.

g. For native bunchgrasses minimize the severity of grazing when grasses are most susceptible by:

* Grazing no field more than half the growing season.
* Grazing only 1 in 3 years during the critical period (2 out of 3 for introduced jointed).
* Deferring each field 1 out of every 3 years during the growing season.

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TABLE 1

PLANT PHENOLOGY

For

Bluebunch Wheatgrass

Ephrata, Washington
1500' Elevation

K. Guinn 1/94

GROWTH STAGE	1988	1989	1990	1991	1992	1993	1994	7-YEAR Average
7-8" Leaves	3/20	4/02	3/22	3/28	3/01	4/11	3/20	3/24
Boot	4/18	4/18	4/10	4/21	3/25	4/25	4/10	4/14
Seedheads Out	5/10	5/04	4/22	5/01	4/12	5/16	5/01	5/01
Anthesis	5/30	5/25	5/06 5/27	5/20 6/02	5/10	5/23	5/14	5/18
End Soft Dough	6/10	6/11	*6/01	*6/23	5/31	6/05		6/10
Seed Shatter	6/19	6/25	N/A	6/30	6/07	6/27		6/20
Critical Period:								
	4/15	4/15	4/05	4/20	3/20	4/20	4/10	4/10
	6/15	6/15	6/05	6/25	6/05	6/20		6/15
Number Days	61	61	61	66	78	61		65
End of Deferment Period:								
	6/15	6/15	6/05	6/25	6/05	6/20		6/15

* No seed formation in 1990.

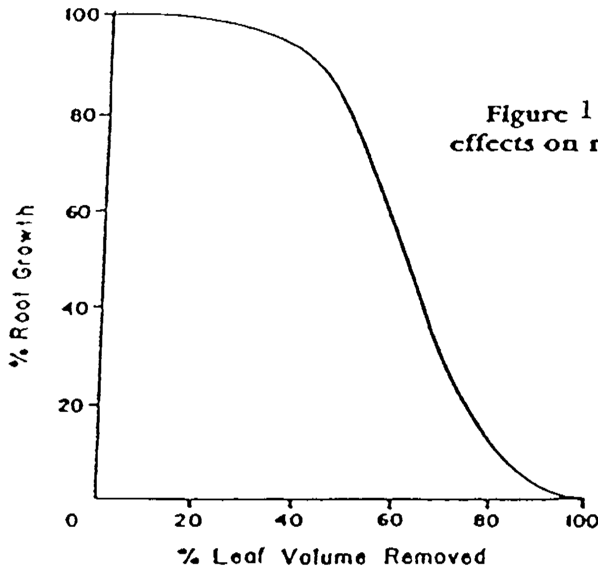

Figure 1 Defoliation effects on root growth.

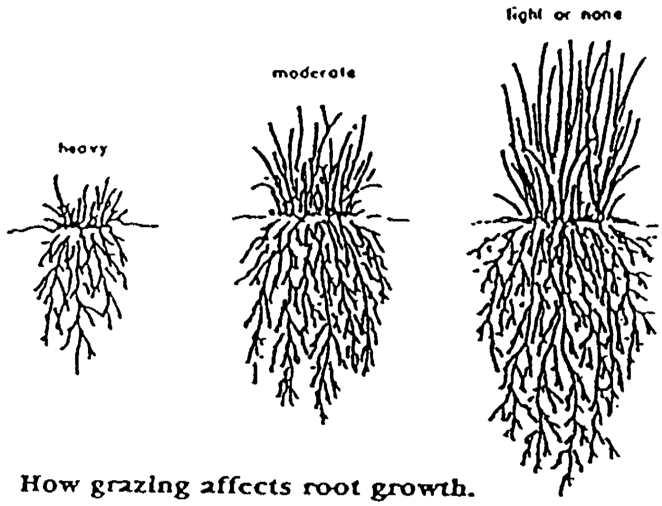

Figure 2 How grazing affects root growth.

A temporary lack of root growth following defoliation may not be entirely detrimental to a grass. Crested wheatgrass reduces root growth following defoliation whereas bluebunch wheatgrass does not. By reducing root growth, crested wheatgrass is able to allocate more resources to shoot regrowth, thus re-establishing the balance between the root and shoot systems (Richards 1984). Because carbohydrates necessary for

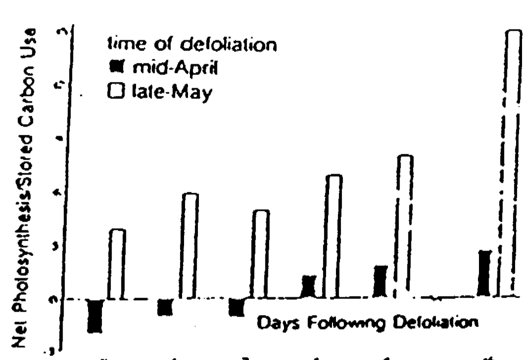

Figure 3 Carbon balance of bluebunch wheatgrass following a severe defoliation on day zero in April and late May. Adapted from Richards and Caldwell 1985.

TECHNICAL NOTES

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

RANGE 35

Spokane, Washington
August 1994

HOW COOL SEASON GRASSES GROW AND PLANT NEEDS

by

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Spokane, Washington

A. Grass Parts (Figure 1)

1. Leaves (Flowers)
2. Stems (Rhizomes and Stolons)
3. Roots

B. Plants Must Have Adequate:

1. Space

   a. Soil depth.
      * Water holding capacity.
      * Fertility storage capacity.

   b. Sufficient sunlight to meet their needs.

   c. Plant numbers.
      * Too many may stunt growth.
      * Too few or inadequate top growth allows weed invasion.

2. Water and Nutrients

   a. Function of water - actively growing grasses are 75% to 90% water.
      * Necessary for photosynthesis.
      * Minerals must be dissolved in water before they are taken up by the roots.
      * Plant cooling agent.

* Water is the major limiting factor to rangeland plants.

* Adequate moisture during the last half of the growing season will not compensate for an inadequate moisture supply during the first half.

b. Nutrients

* From air: carbon dioxide.

* Carbon dioxide is second to water as a leading element for grass growth.

* Of the elements required for grass growth about 95% are taken from the air and only 5% from the soil (if water is not included).

* Plants use phosphorous, nitrogen, potash, calcium, magnesium, and sulfur in large quantities to manufacture their food. They use other minerals such as iron, copper, boron, manganese, molybdenum, and zinc in small quantities but must have them for good plant growth.

* Sources of nitrogen on rangeland:

- Rain
- Decomposition of grass roots and shoots
- Animal excretion
- Some legumes such as lupine and vetch

3. Root System

a. Functions of the older portion of root system:

* Anchors the plant.

* Binds the soil.

b. Functions of new portion of root system:

* Extracts mineral elements and water from soil particles.

* Replaces the older roots that become inactive.

c. Root Replacement

* Each year a portion of a grass plant's roots die and are replaced.

* Amount of annual replacement ranges from 20-50% of the total root system.

* Growing roots require food from the leaves and water from the soil.

4. Top Growth

a. The leaves and stems are where plants make their own food.

b. Stems are the support structure for the plant and transport water and nutrients to and from the above ground portion and the roots.

c. The amount of top growth directly affects the plants total water absorption and transpiration.

d. Nutrient storage.

5. Relationship between top growth and root system. (Figure 2)

   a. Vigorous top growth is essential in order to maintain a healthy root system which in turn results in a grass plant that produces abundant forage and is more tolerant of drought and other stresses.

   b. A small top growth can only support a small root system.

C. **Plants Make Their Own Food Through A Process Called PHOTOSYNTHESIS. (Figure 3)**

1. Photosynthesis is an energy-capturing process.

2. In the presence of sunlight, a simple sugar, glucose, is formed when water and carbon dioxide are fixed in chlorophyll, the green tissue of the plants (carbon fixation).

3. The sugars then combine with the minerals elements from the soil to make proteins, plant oils, and fats that the plant needs to grow and reproduce itself.

4. Photosynthesis is limited to periods when plants have green leaves, stems or both and favorable water and temperature conditions.

   a. Cool season plants.

   b. Warm season plants.

D. **Food Storage**

1. Location

   a. Lower stem bases for most grasses.

   b. Rhizomes (examples - saltgrass, smooth brome, reed canarygrass).

   c. Seeds for annuals (example - cheatgrass).

   d. Roots in forbs (example - legumes).

   e. Branches and roots (shrubs and trees).

2. Uses

   a. To support tiller recruitment and growth after defoliation when photosynthesis is low.

   b. To develop heat and cold resistance.

   c. To support metabolism during periods of dormancy.

   d. To promote flower and seed formation.

E. **Tillers Are The Basic Unit Of Grasses (Figure 4)**

1. Tillers and Bunchgrasses

   a. Tillers are composed of growing points, stems, leaves, nodes and dormant buds (Figures 5 and 6)

   b. Individual grass plants are composed of several tillers which originated from axillary buds of older parental tillers.

c. Each tiller establishes a shoot and root system to acquire resources.

d. A bunchgrass is a collection of individual tillers with some shared facilities. The analogy would be an apartment house of clones. A study by Olson and Richards (1988) showed that an ungrazed tiller does not enhance the growth potential of an unrelated heavily grazed tiller on the same plant. Food is not transferred through the root and crown system to needy tillers. A parent tiller will support a daughter tiller.

e. Generally tillers have: an emerging leaf, an immature leaf, a mature leaf and a senescing leaf.

2. Tiller Recruitment

a. Tiller recruitment occurs mostly in the spring and fall. Thus, the fall green up is not free forage but is the basis for next year's production. Fall recruitment of tillers only occurs if there is sufficient moisture available.

b. Fall or early spring initiated tillers provide the most production because they have a longer period for growth and development. The number of tillers in a plant determines the potential for the total production within the constraints of resource availability.

3. Intercalary Meristems

a. Intercalary meristems (areas of cell division or growth) are located at the base of the leaf blade and sheath, and at the internode.

b. Result in the growth of the leaf blades, sheath and internode.

c. The growth of the leaf blade and sheath stop when the ligule is fully developed.

d. The basal location of the intercalary meristem within the blade and sheath explain why leaf growth can occur following defoliation as long as the leaf has not matured.

e. Internode elongation is dependent upon species and phenology. Generally, it occurs as the apical meristem becomes reproductive but in some grasses it occurs in the vegetative stage of the plant. When internode elongation occurs it raises the apical meristem above ground level.

4. Axillary Buds

a. The apical meristem produces axillary buds at the nodes of the grass plant.

b. If the apical meristem is removed the axillary bud will produce a new tiller if there is adequate moisture.

5. Leaf Replacement Potential

a. The rate at which the leaf area is regrown following defoliation is a function of the number, source and location of meristems within the plant.

b. Growth will occur most rapidly from immature intercalary meristems (blade, sheath) and least rapidly from newly initiated axillary buds.

c. When the apical meristem becomes reproductive or is removed by grazing, leaf replacement must originate from axillary buds which require the greatest amount of time for regrowth. This is why grasses that have a high ratio of reproductive or culmed vegetative tillers (jointed grasses) are best suited to intermittent grazing.

F. **Longevity Of Perennial Grasses Depend On The Successive Production Of Short Lived Tillers.**

1. The dead centers of many perennial grasses are a natural development rather than a negative response to stress.
2. Tiller longevity in perennial grasses is usually less than 1 year.
3. Grasses must have more than a 1:1 ratio of tiller replacement to increase in size.
4. If tiller recruitment was stopped for the time equal to the life of the existing tillers, the plant would loose its growing points and die.
5. Changes in tiller density occurs when tiller recruitment lags behind or exceeds tiller mortality. (Figure 7)
6. Reproductive tiller development terminates with seed maturity; vegetative tiller mortality is the consequence of shading of smaller tillers, and less carbon allocation to young tillers from parental tillers may be more important. (Figure 8)

G. **Axillary Buds And Growing Points Give Rise To and Regulate All Growth.**

1. With the right conditions axillary buds start growth in the fall, although in spring also for many species.
2. Apical meristem (Figures 5, 6, and 8).

   a. Controls the growth of the tillers and all growth initially originates from the apical meristem.

   b. Continues to grow (produce intercalary meristems) as long as the apical meristem is in the vegetative state.

   c. The apical meristem produces the seedhead. (Figure 8)

   d. Once the apical meristem becomes reproductive (in the boot stage) the plant is committed to reproduction and its ability to produce new phytomers and leaves specifically is at a low level and declining. **This is the most critical period for the grass (boot stage through soft dough stage).**

   e. When the apical meristem becomes reproductive or is removed by defoliation - begetative growth can only occur from immature intercalary meristems (leaf blade and sheath) or from axillary buds. Axillary bud development is dependent on soil moisture so there may not be adequate soil moisture for regrowth.

   f. The type of grass determines when the apical meristem is elevated. Once the apical meristem is elevated it is susceptible to removal by grazing or mowing. If the growing point is removed, that tiller cannot grow and new growth must come from axillary buds which reduces next years crop.

H. Growth Cycle (Figures 9 and 10)

(Growth from inception to maturity is quite similar in all grasses.)

1. Fall/Winter

   a. If there is adequate moisture new tillers start in the fall from axillary buds.

   b. These tillers overwinter in the 1-3 leaf stage.

2. Spring Vegetative Growth

   a. Expanding young leaves use most of the carbohydrates they produce and also import some carbon from older leaves that are mature or draw on carbohydrate pools.

   b. Photosynthesis from fall initiated tillers is generally adequate to meet the needs of the plants for initiation of spring growth.

   c. Only a small portion of the stored carbohydrates is used for the start of spring growth.

   d. As spring growth begins, the apical meristem (growing point) is inside the stem, near the base of the plant. Whether or not the apical meristem is elevated during the growing season depends on the type of grass plant and stage of growth.

   e. The phenology (state of development) of a plant is primarily dependent upon air temperature which is expressed as growing degrees.

3. Late Spring/Summer Reproductive Growth

   a. Fall initiated tillers have the greatest chance of becoming reproductive, thus tillers initiated in the spring generally will not flower.

   b. Most cool-season grasses (almost all of the native range grasses in Eastern Washington), require tiller initiation in the fall and exposure to cold temperature for formation of reproductive structures.

   c. During stem elongation (reproductive growth) the apical meristem is already forming an inflorescence and elevates above the ground, becoming susceptible to removal.

4. Regrowth

   a. Within 3 days following defoliation, photosynthesis provides from 88% to 99% of the regrowth in bluebunch wheatgrass; the remainder is supplied from carbohydrate pools stored food). The carbohydrate pools should be considered small buffers for regrowth, not large reserves.

   b. The most critical factor affecting regrowth is the amount of green leaf and stem tissue remaining after defoliation. The more green leaf area remaining after a grazing period, the greater the potential for regrowth. Favorable growing conditions are required.

c. Under range conditions there may not be enough moisture for axillary buds; the quickest regrowth comes from leaves and stems on existing tillers; we just cannot expect a lot of regrowth under range conditions.

I. Establishment of Seedlings

1. Plants may reproduce by tillering, rhizomes and stolons, or seeds.

2. Reproduction by seed is the most common method among the higher plants and the only method of many perennials and all annuals.

3. The seedling depends on the rapid development of its own roots to supply it with moisture. In drought years, the seed may not germinate or the seedling may die before it can send its roots down to the moist subsoils. Annuals such as cheatgrass are serious competitors to young perennial plants because of its rapid root growth and the early initiation of growth.

4. Shrub or forb seeds can remain for a period of 5-10 years, some much longer, allowing the plant to survive prolonged drought periods or other disturbances.

5. Grass seeds are viable for only 1-2 years; there is not a soil bank of grass seeds; in good years grasses must produce seed and then the next year must germinate and recruit seedlings.

J. Types of Grasses (Figure 12)

1. Bunchgrasses or Jointed Grasses (bluebunch wheatgrass, Idaho Fescue, crested wheatgrass, etc.)

    a. Have a high ratio of reproductive or culmed vegetative tillers.

    b. Internode elongation elevates the apical meristem above the ground surface where it can be removed by defoliation.

2. Sodforming or non-jointed grasses (orchardgrass, tall fescue, Kentucky bluegrass, etc.

    a. Less than 10% of the stems are jointed and produce seedheads.

    b. The growing point on the other stems remain close to the ground during the growing season. The leaves and tillers can continue to elongate even though a portion of the leaves have been removed by grazing or mowing.

    c. Forage production comes from continued leaf growth at the junction of the blade and collar and base of sheath (intercalary meristem). If the intercalary meristem is not removed, the leaf will continue to grow as long as there is adequate moisture.

    d. If the intercalary meristem is allowed to grow too high it can be removed. Once the intercalary meristem is removed the growth stops because the source of regrowth is gone. New growth must come from axillary buds which take time to start growing.

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PARTS of GRASS PLANTS

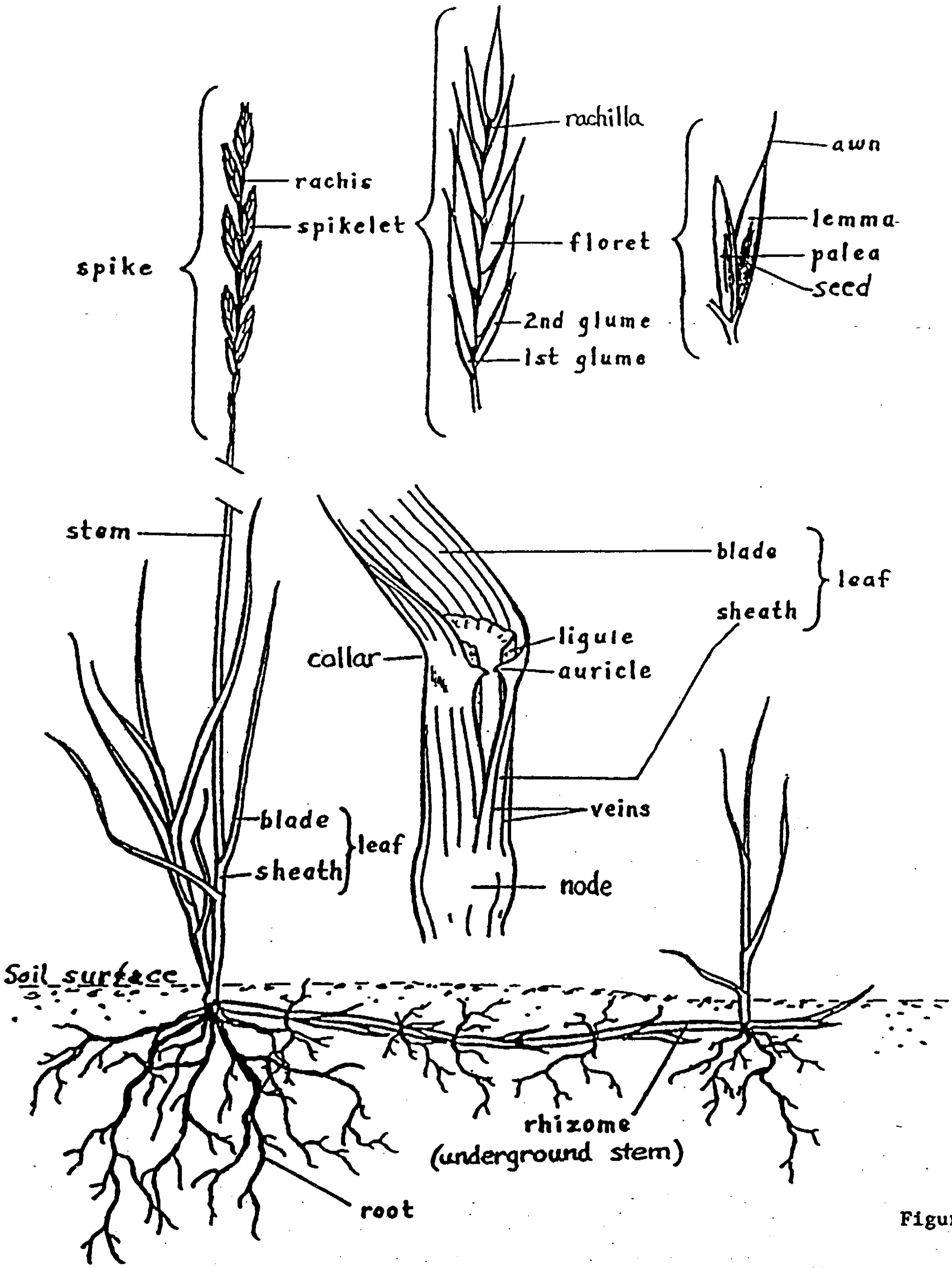
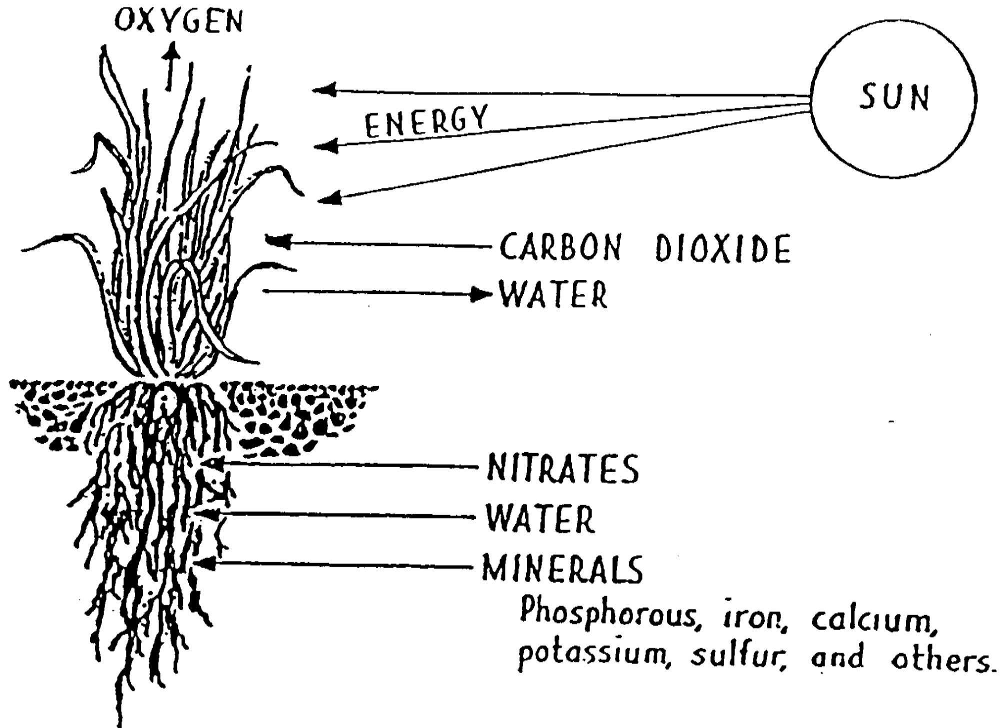


Figure 1



HOW GRASS OBTAINS MATERIALS FOR FOOD MANUFACTURE

Figure 2

A. Although you may think you see quite a bit of "daylight" between grass plants in even your best pastures, actually the plants are properly spaced. Notice how the roots intermingle and the leaf canopy prevents sunlight from reaching other plants such as weeds. B. Each year approximately 30 percent of each grass plant's root system must be replaced. What happens if you overgraze and the plant's root system not only can't expand, but can't replace that vital 30 percent natural loss? C. Weeds can take hold and grow where grass roots have been too severely weakened. Weedy pasture is less productive pasture.

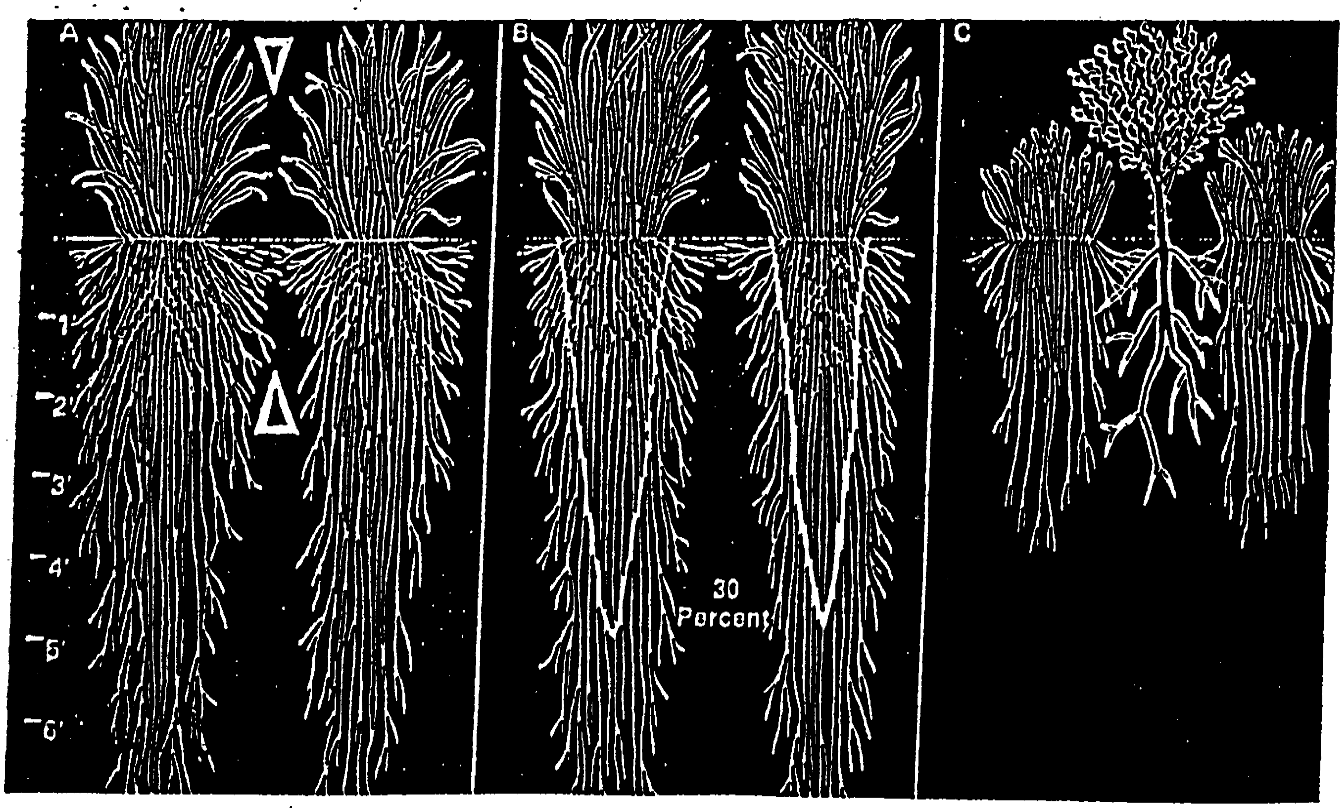


Figure 3

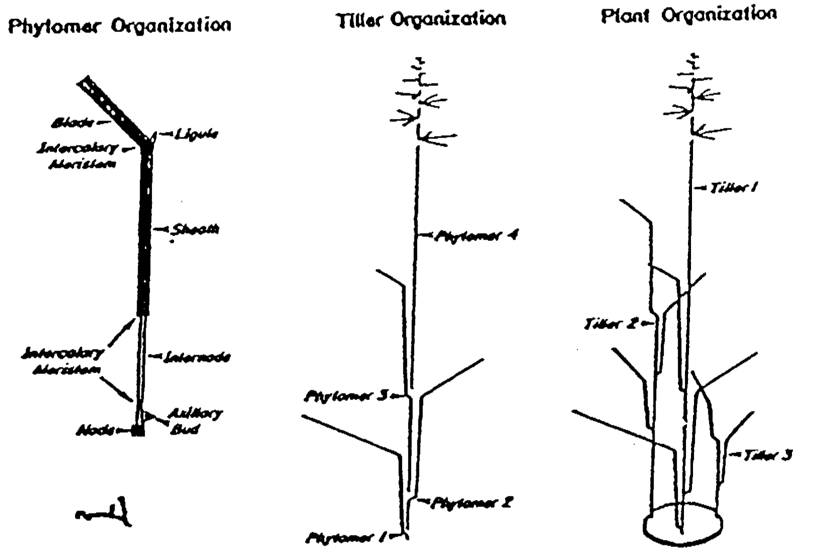


Figure 4

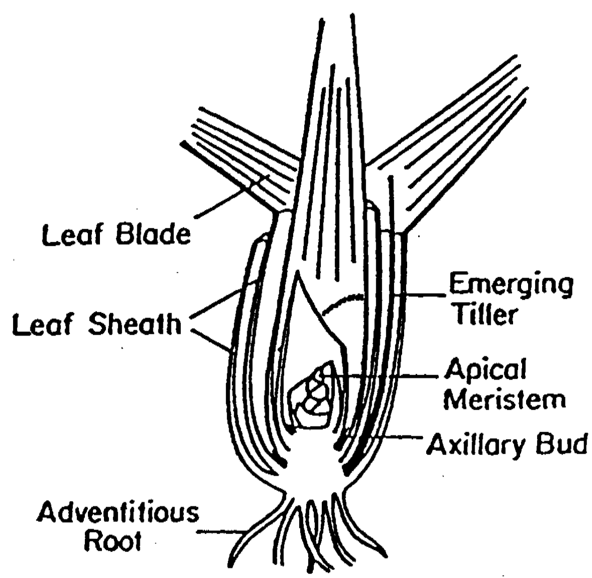
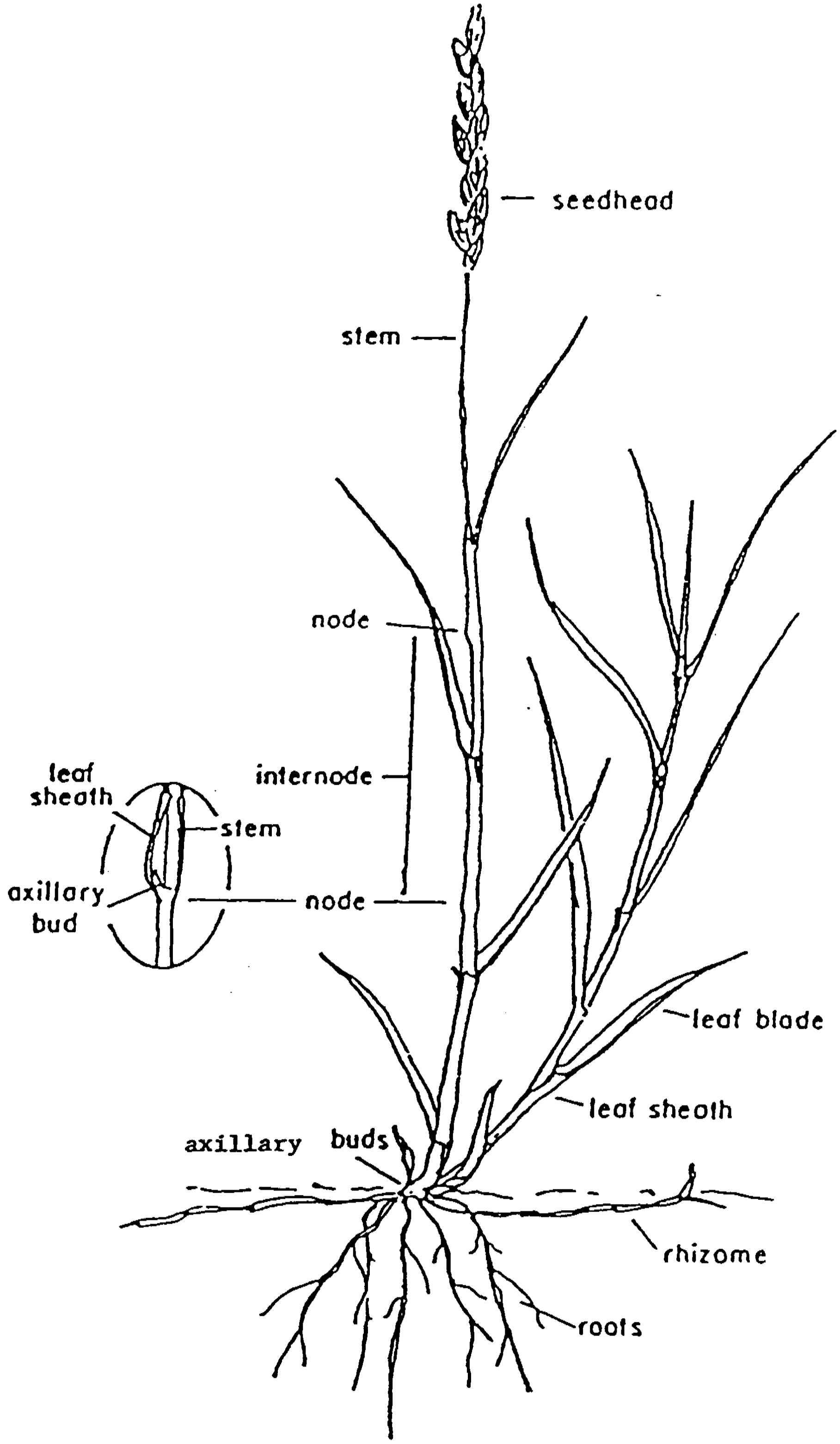


Figure 5 **Tiller initiation from axillary buds in the crown of a grass plant. Axillary buds contain single rudimentary apical meristems capable of differentiating a complete tiller (from Jewiss 1972).**



gure 6 Structure of the grass plant and location of buds at can grow into tillers. The main growing point has atured into a seed head.

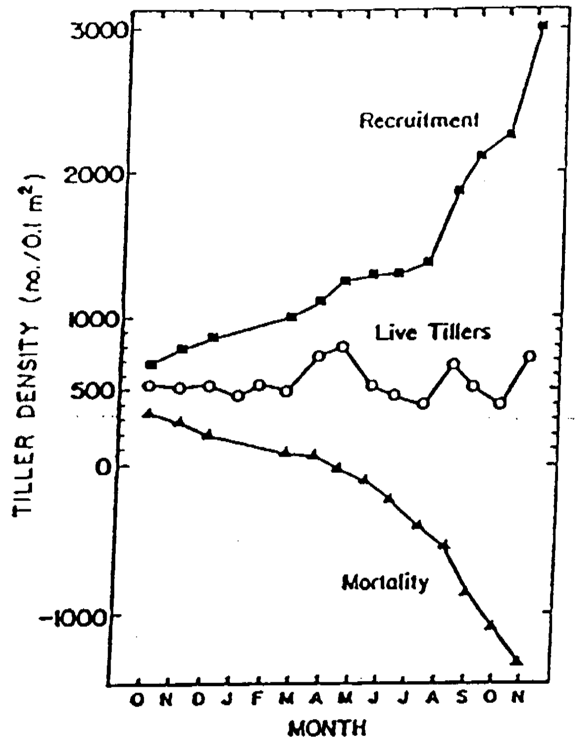


Figure 7 Live tiller density as a consequence of tiller recruitment and mortality within a population. Tiller density increases when recruitment exceeds mortality and decreases when recruitment lags behind mortality (from White 1980).

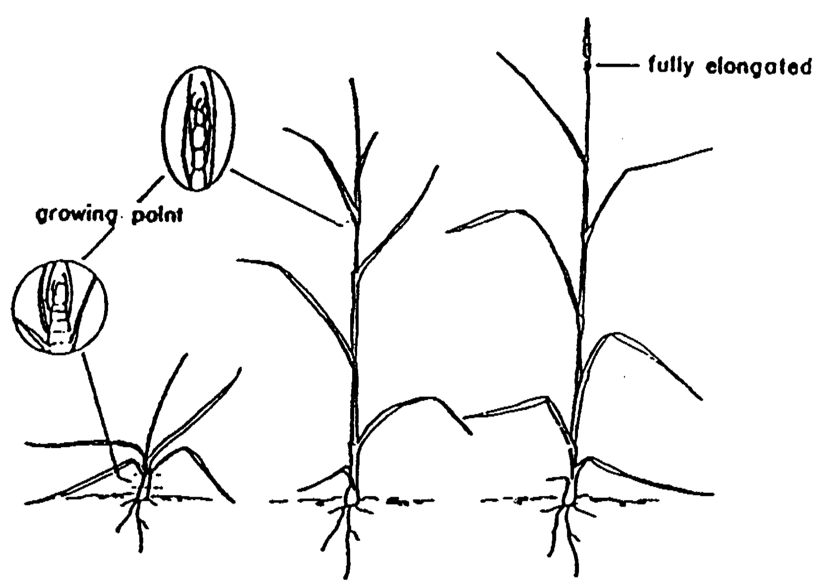


Figure 8 Developmental phases of a grass tiller.

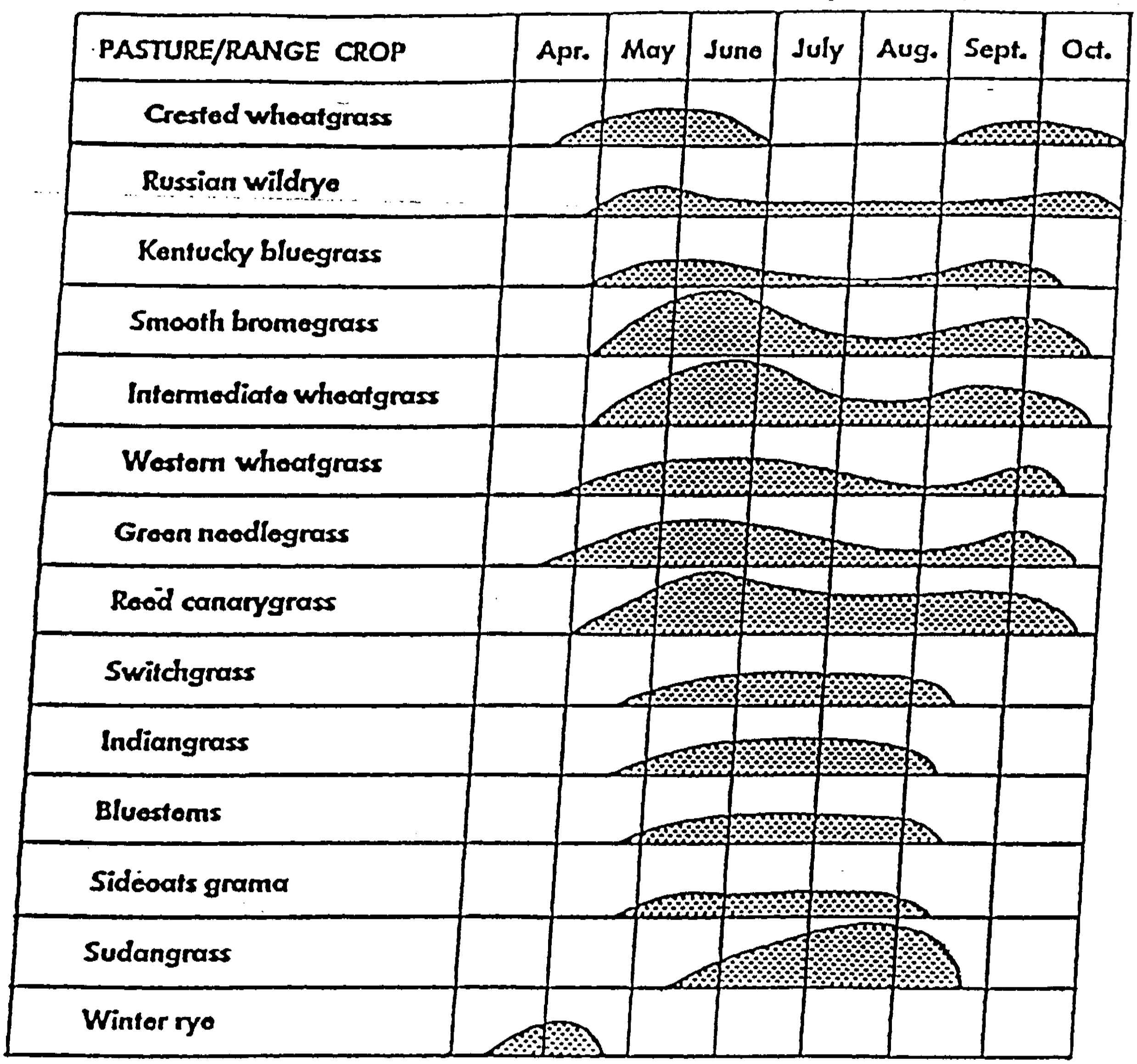

PASTURE/RANGE CROP
Apr.
May
June
July
Aug.
Sept.
Oct.
Crested wheatgrass
Russian wildrye
Kentucky bluegrass
Smooth bromegrass
Intermediate wheatgrass
Western wheatgrass
Green needlegrass
Reed canarygrass
Switchgrass
Indiangrass
Bluestems
Sideoats grama
Sudangrass
Winter rye

Figure 9

GROWTH CURVE OF BLUE BUNCH WHEATGRASS AT VARIOUS GROWTH STAGES

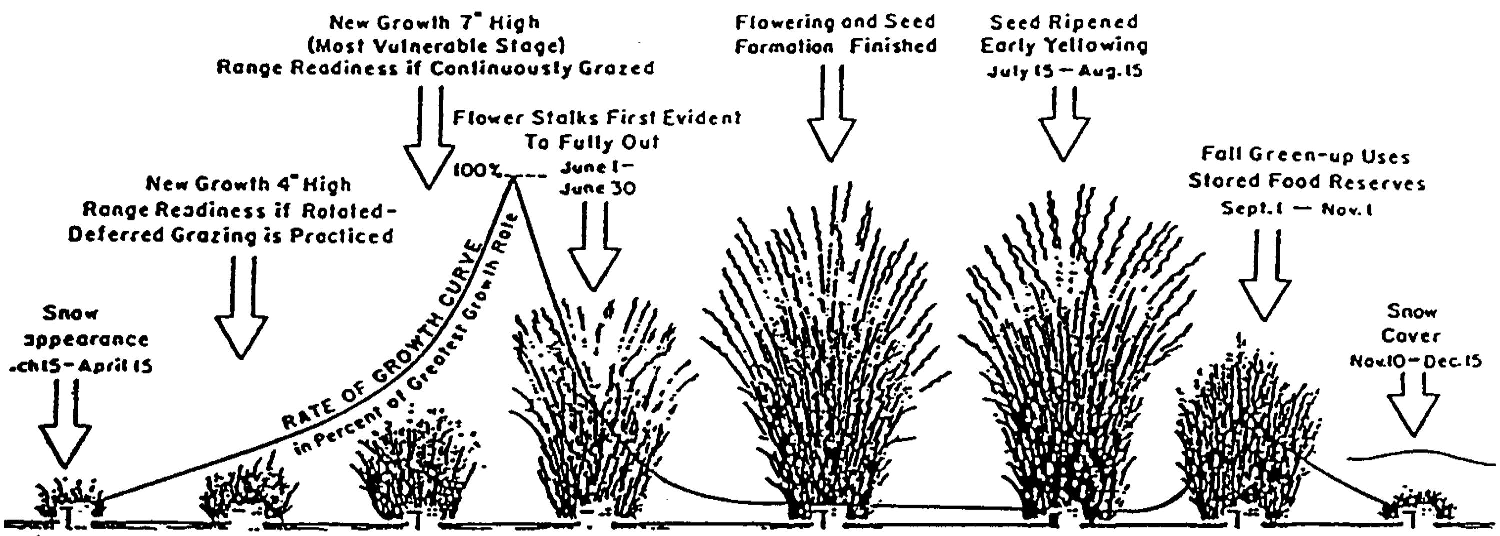


Figure 10

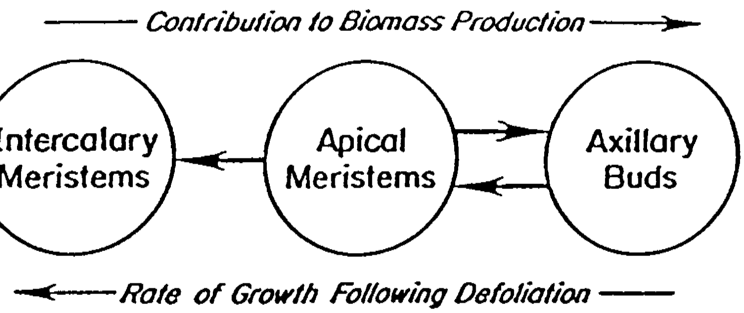


Figure 11 Sources of meristematic activity in a grass plant. The relative growth rate from each source following defoliation is established by the extent to which tissue differentiation has previously occurred. Axillary buds confer perenniality to the plant while intercalary meristems are relatively short-lived (from Briske 1986).

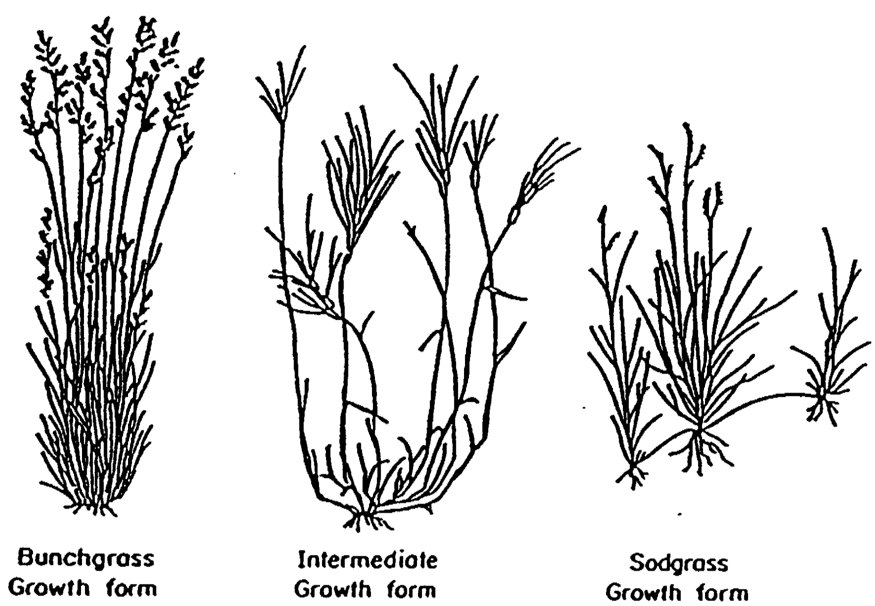


Figure 12 Variation within the grass growth form originates from the pattern of tiller emergence expressed by various species groups. The bunchgrass growth form originates from intravaginal tiller development, while extravaginal tiller development contributes to a more diffuse tiller arrangement and serves as a prerequisite to the sodgrass growth form. Stolons or rhizomes further increase inter-tiller distances within plants.

Appendix F

Planning for Drought

Planning for drought could consume time and resources, especially if a multi-agency approach is utilized. However, if each agency plans for drought independent of other agencies or state and private landowners the site-specific and collateral impacts from independent decisions made on these lands will probably cause long-term negative impacts on the economy and environment of Utah, which will certainly cause social change. Consequently, the DA&MT suggests that a statewide drought planning effort will pay positive long-term dividends from the investment of time and resources will be worth the short-term pain.

Step 1: Appoint a Drought Task Force

A drought planning process in Utah would be very successful if it followed the multi-agency/multi-disciplinary approach used in the Drought Assessment and Mitigation Team process and if the effort were initiated by the governor.

The task force has two purposes. First, the task force supervises and coordinates development of the plan. Second, after the plan is developed and during times of drought when the plan is activated, the task force coordinates actions, implements mitigation and response programs, and makes policy recommendations to the governor. The task force is encouraged to oversee development of a website that would contain information about the planning process, a copy of the plan, and current climate and water supply information.

The task force should reflect the multidisciplinary nature of drought and its impacts, and it should include representatives of both state and federal government agencies and universities (e.g., representatives from extension, climatologists, policy specialists, planners). A representative from the governor's office should be a member of the task force. Environmental and public interest groups and others from the private sector, including industries, can be included on the task force, and/or on sector-specific working groups of the risk assessment committee, or an advisory council, or they can be otherwise involved, as appropriate. The actual makeup of this task force would be highly variable between states, reflecting the state's political and economic character.

Depending on the nature of recent experiences with drought, the task force may find itself in the public spotlight from the outset, or it may work in relative obscurity. No matter what the initial level of public attention is, the task force needs to incorporate people who know how to conduct effective two-way communication with the public. Ideally, the task force should include or have access to a public information official that is familiar with local media's needs and preferences and a public participation practitioner who can help establish processes that accommodate both well-funded and disadvantaged groups.

Step 2: Define the Purpose and Objectives of the Drought Plan

As its first official action, the drought task force should develop and state the general purpose for the drought plan. State and agency officials should consider many questions as they define the purpose of the plan, such as:

- purpose and role of state government and state and federal agencies in drought mitigation and response efforts;
- scope of the plan (e.g. will it include urban water use, public and private land assessment and mitigation, etc.;
- define the role of citizens and NGOs;
- identify the most drought-prone areas of the state;
- assess the historical impacts of drought;

- assess the historical response to drought;
- identify the most vulnerable economic and social sectors;
- clearly define and articulate the role of the plan in resolving conflict between water users and other vulnerable groups:
- during periods of shortage;
- current trends (e.g., land and water use, population growth) that may
- increase/decrease vulnerability and conflicts in the future;
- resources (human and economic) that the entities are willing to commit to the planning process;
- legal and social implications of the plan;
- principal environmental concerns caused by drought.

A generic statement of purpose for a plan is to reduce the impacts of drought by identifying principal activities, groups, or regions most at risk and developing multi-agency mitigation actions and programs that alter these vulnerabilities. The plan is directed at providing government agencies and state leadership with an effective and systematic means of assessing drought conditions, developing mitigation actions and programs to reduce risk in advance of drought, and developing response options that minimize economic stress, environmental losses, and social hardships during drought.

The task force should identify the specific objectives that support the purpose of the plan. Drought plan objectives should reflect the unique physical, environmental, socioeconomic, and political characteristics of the state of Utah. At the state level, plan objectives will place less emphasis on financial assistance measures (traditionally a role of the federal government in the United States) than would the objectives of a national plan. Technical assistance is a common element of state agency missions. Support for educational and research programs is typically a shared responsibility of state and federal government. Objectives that states should consider include the following:

- Collect and analyze drought-related information in a timely and systematic manner.
- Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.
- Provide an organizational structure and delivery system that assures information flow between and within levels of government.
- Define the duties and responsibilities of all agencies with respect to drought.
- Maintain a current inventory of state and federal programs used in assessing and responding to drought emergencies.
- Identify drought-prone areas of the state and vulnerable economic sectors, individuals, or environments.
- Identify mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web).
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state.

Step 3: Seek Stakeholder Participation and Resolve Conflict

Social, economic, and environmental values often clash as competition for scarce water resources intensifies. Therefore, it is essential for task force members to identify all citizen groups and NGO's that have a stake in drought planning (stakeholders) and their interests. These groups must be involved early and continuously in order for there to be fair representation and effective drought management and planning. Discussing concerns early in the process gives participants a chance to develop an understanding of one another's various viewpoints, and to generate collaborative solutions. Although the level of involvement by these groups will vary notably from area to area, the power of public interest groups in policy making is considerable. In fact, these groups are likely to impede progress in the development of plans if they are not included in the process. The task force should also protect the interests of stakeholders who may lack the financial resources to serve as their own advocates.

Public participation takes many forms. Time and money may constrain how actively the task force can solicit input from stakeholders. One way to facilitate public participation is to establish a citizen's advisory council as a permanent feature of the drought plan, to help the task force keep information flowing and resolve conflicts between stakeholders. Another way is to invite stakeholders to serve on working groups of the risk assessment committee.

The state wide Drought Planning Task Force should also consider whether district or regional advisory councils need to be established. These councils could bring neighbors together to discuss their water use issues and problems and seek collaborative solutions. At the state level, a representative of each district council should be included in the membership of the state's citizens' advisory council to represent the interests and values of their constituencies. The state's citizens' advisory council can then make recommendations and express concerns to the task force as well as respond to requests for situation reports and updates.

Step 4: Identify Resources and Identify Groups at Risk

An inventory of natural, biological, and human resources, including the identification of constraints that may impede the planning process, may need to be initiated by the task force. In most states in the United States, much information already exists about natural and biological resources through various state and federal agencies. It is important to determine the vulnerability of these resources to periods of water shortage that result from drought. The most obvious natural resource of importance is water: where is it located, how accessible is it, of what quality is it? Biological resources refer to the quantity and quality of grasslands/rangelands, forests, wildlife, and so forth. Human resources include the labor needed to develop water resources, lay pipeline, haul water and livestock feed, develop resource reserves, implement the systematic maintenance of public land water projects, process citizen complaints, provide technical assistance, and direct citizens to available services.

It is also imperative to identify constraints to the planning process and to the activation of the plan in response to a developing drought. These constraints may be physical, financial, legal, or political. The costs associated with the development of a plan must be weighed against the losses that will likely result if no plan is in place. The purpose of a drought plan is to reduce risk and therefore economic, social, and environmental impacts. Generally speaking, the costs associated with the development of a state-level plan have been $50,000-$100,000, plus in-kind costs to state and federal agencies. This price tag seems inconsequential in comparison to the impacts associated with drought. Legal constraints can include water rights, existing public trust laws, and requirements for public water suppliers, liability issues, and so forth.

In drought planning, making the transition from crisis to risk management is difficult because, historically, little has been done by state and federal agencies to understand and address the risks associated with drought. To solve this problem, areas of high risk should be identified, as should actions that can be taken before a drought occurs to reduce those risks. Risk is defined by both the exposure of a location to the drought hazard and the vulnerability of that location to periods of drought-induced water shortages.[i]. Drought is a natural event; it is important to define the exposure (i.e., frequency of drought of various intensities and durations) of various parts of the state to the drought hazard. Some areas are likely to be more at risk than others. Vulnerability, on the other hand, is defined by social factors such as land use patterns, government policies, social behavior, water use, population, economic development, diversity of economic base, cultural composition, and so forth. The drought task force should address these issues early in the planning process so they can provide more direction to the committees and working groups that will be developed under Step 5 of the planning process.

Step 5: Develop Organizational Structure and Prepare the Drought Plan

These steps describes the process of establishing relevant committees to develop and write the drought plan and develop the necessary organizational structure to carry out its responsibilities. The drought plan should have three primary components: monitoring, risk assessment, and mitigation and response. It is recommended that committees be established to focus on the first two of these needs; the mitigation and response function can in most instances be carried out by the drought task force (Figure 1).

These committees will have their own tasks and goals, but well-established communication and information flow between committees and the task force is a necessity to ensure effective planning.

Task Force (Mitigation and Drought Response)

It is recommended that the task force (see Step 1), working in cooperation with the monitoring and risk assessment committees, have the knowledge and experience to understand drought mitigation techniques, risk analysis (economic, environmental, and social aspects), and drought-related decision-making processes at all levels of government. The drought task force, as originally defined, is composed of senior policy makers from various state and federal agencies. The group should be in an excellent position to recommend and/or implement mitigation actions, request assistance through various federal programs, or make policy recommendations to the legislature and governor.

Specific responsibilities of the task force at this point are to:

A. Determine mitigation and response actions for each of the principal impact sectors, in close cooperation with the risk assessment committee. Wilhite (1997) recently completed an assessment of drought mitigation technologies implemented by states in response to drought conditions during the late 1980s and early 1990s (http://drought.unl.edu/mitigate/tools.htm). However, the transferability of these technologies to specific situations in other states needs to be evaluated further because they may not be directly transferable in some cases. Working with the risk assessment committee, the task force should come up with recommendations addressing drought on two different time scales:

- Short-term responses to implement during drought, such as voluntary water conservation guidelines, a ready-to-roll hay hotline, streamlined administrative procedures for evaluating emergency assistance applications, and pre-produced infomercials leading agricultural producers and citizens to information on best management practices.

- Long-term drought mitigation projects, such as education programs to give various audiences the background they need to interpret drought news reports or scientific drought indices; programs to persuade people to adopt measures that enhance organic content in soil, conserve water, and otherwise boost the resilience of natural and social systems that are vulnerable to drought. Other projects include regional seminars about preparing for drought on private lands, using various alternative economic models to manage for average conditions (which factors in drought years) instead of optimum conditions on private lands.

Assuming there is no ongoing drought, it's a good idea to publicize the recommendations of the task force and seek public input before the plan is implemented, particularly if anything seems revolutionary or controversial.

B. Inventory all forms of assistance available from local, state, and federal government agencies during severe drought. The task force should evaluate these programs for their ability to address short-term emergencies and long-term vulnerability to drought. Assistance should be defined very broadly to include all forms of technical, mitigation, and relief programs available. Drought program inventories are available on the web: the Catalog of Federal Assistance Programs and the National Drought Policy Commission's analysis, although it's important to note that the NDPC listing includes programs that have never been funded.

C. Work with the monitoring and risk assessment committees to establish triggers. The monitoring committee can advise the task force on which drought and water supply indices are most relevant for the state or region. It is helpful to establish a sequence of descriptive terms for water supply alert levels, such as "advisory," "alert," "emergency," and "rationing" (as opposed to more generic terms such as "phase 1"and "phase 2," or sensational terms such as "disaster"). The task force should review the terminology used by other entities (i.e., local utilities, states, river basin) and choose terms that are consistent in areas where authorities may technical assistance or other forms of encouragement to help local water suppliers establish triggers for different stages of rationing before a drought. Some states, such as California, mandate that every water supplier have a drought contingency plan.

D. Establish drought management areas (i.e., subdivide the state or region into more conveniently sized districts by political boundaries, shared hydrological characteristics, climatologically characteristics, or other means such as drought probability or risk). These subdivisions may be useful in drought management since they may allow drought stages and mitigation and response options to be regionalized.
Climatic divisions are the most commonly used subdivisions at the state level, but they may not be the most appropriate, given topographic features, land use patterns, or water use characteristics. The task force should work closely with the monitoring committee to understand natural boundaries as well as limitations imposed by existing data collection systems, and with the risk assessment committee to understand the timing of drought's effects on different economic sectors and social groups.

E. The drought task force should develop a website for disseminating drought monitoring information and for letting the public know about the drought plan. Models that could be followed are web pages for the states of Texas, Montana, Pennsylvania, Oklahoma, New Mexico, South Carolina, and Nebraska (http://drought.unl.edu/plan/stateplans.htm and http://drought.unl.edu/plan/handbook/other_web_links.htm.

Monitoring Committee

A reliable assessment of water availability and its outlook for the near- and long-term is valuable information in both dry and wet periods. During drought, the value of this information increases markedly. The monitoring committee should include representatives from agencies with responsibilities for monitoring climate and water supply. It is recommended that data and information on each of the applicable indicators (e.g., precipitation, temperature, evapotranspiration, long-range weather forecasts, soil moisture, streamflow, ground water levels, reservoir and lake levels, and snow pack) be considered in the committee's evaluation of the water situation and outlook for the state. The agencies responsible for collecting, analyzing, and disseminating data and information will vary according to the state organizational structure and by geographic region.

The monitoring committee should meet regularly, especially in advance of the peak demand season. Following each meeting, reports should be prepared and disseminated to the state's drought task force, relevant state and federal agencies, and the media. The chairperson of the monitoring committee should be a permanent member of the drought task force. In many states, this person may be the state climatologist. If conditions warrant, the task force should brief the governor about the contents of the report, including any recommendations for specific actions. It is essential for the public to receive a balanced interpretation of changing conditions. The monitoring committee should work closely with public information specialists to keep the public well informed.

The primary objectives of the monitoring committee are to:

A. Help policy makers adopt a workable definition of drought that could be used to phase in and phase out levels of state and federal actions in response to drought. It may be necessary to adopt more than one definition of drought in identifying impacts in various economic, social, and environmental sectors. Several indices are available (Hayes, 1998), including the Standardized Precipitation Index (McKee et al., 1993; 1995), which is gaining widespread acceptance (Guttman, 1998; Hayes et al., 1999; also refer to http://drought.unl.edu/monitor/spi.htm). The commonly used Palmer Drought Severity Index (Palmer, 1965) is being replaced or supplemented as a monitoring tool in many states. The trend is for states to rely on multiple drought indices as indicators of impacts in various sectors. The current thought is that no single index of drought is adequate to measure the complex interrelationships between the various components of the hydrological cycle and impacts.

B. Help the task force establish drought management areas (i.e., subdivide the state or region into more conveniently sized districts by political boundaries, shared hydrological characteristics, climatological characteristics, or other means such as drought probability or risk). The monitoring committee's advice may be particularly helpful in communicating natural watershed boundaries as well as the limits and constraints imposed by existing data.

C. Develop a drought monitoring system. Most states already have a good data collection system for monitoring climate and water supplies and identifying potential shortfalls. Responsibility for collecting, analyzing, and disseminating the data is divided between many state and federal agencies and other entities. The monitoring committee's challenge is to coordinate and integrate the analysis so decision makers and the public receive early warning of emerging drought conditions. On a national basis, much of this information has been compiled under the Monitoring Drought section of the NDMC's website. Two new products, the Drought Monitor and Current Droughts Affecting the U.S., are good examples. This section is also linked to specific state websites that illustrate how others are organizing information on drought conditions.

Many states (e.g., Nebraska, Oklahoma, California) have developed automated weather data networks that provide rapid access to climate data. These networks can be invaluable in monitoring emerging and ongoing drought conditions. Data from them can be coupled with data available from federal agencies (e.g., Natural Resources Conservation Service) to provide a comprehensive monitoring of climate and water systems. Data and data products should be disseminated on a timely basis in printed form and electronically via the World Wide Web.

D. Inventory data quantity and quality from current observation networks. Many networks monitor key elements of the hydrologic system. Most of these networks are operated by federal or state agencies, but other networks also exist and may provide critical information for a portion of a state or region. Meteorological data are important but represent only one part of a comprehensive monitoring system. Other physical indicators (soil moisture, streamflow, reservoir and ground water levels) must be monitored to reflect impacts of drought on agriculture, households, industry, energy production, and other water users. Helpful technology includes soil moisture sensors, automated weather stations, and satellite data such as digital data obtained from the

Advanced Very High Resolution Radiometer (AVHRR), transmitted from a National Oceanic and Atmospheric Administration satellite, which is useful in detecting areas where moisture deficiencies are affecting vegetation growth. Much of this data will be integrated under the Unified Climate Access Network (UCAN).

E. Work closely with the task force and risk assessment committees to determine the data needs of primary users. Developing new or modifying existing data collection systems is most effective when the people who will be using the data are consulted early and often. Soliciting input on expected new products or obtaining feedback on existing products is critical to ensuring that products meet the needs of primary users and will be used in decision making. Training on how to use or apply products in routine decision-making is also essential.

F. Develop and/or modify current data and information delivery systems. People need to be warned of drought as soon as it is detected, but often they are not. Information needs to reach people in time for them to use it in making decisions. In establishing information channels, the monitoring committee needs to consider when people need various kinds of information. These decision points can determine whether the information provided is used or ignored.

Risk Assessment Committee

Drought impacts cut across many sectors and across normal divisions of responsibility of local, state, and federal agencies. These impacts have been classified by Wilhite and Vanyarkho (2000) and are chronicled in the "Understanding Your Risk" section of the NDMC's website. Risk is the result of exposure to the drought hazard (i.e., probability of occurrence) and societal vulnerability, represented by a combination of economic, environmental, and social factors. Therefore, to reduce vulnerability to drought, it is essential to identify the most significant impacts and assess their underlying causes.

The membership of the risk assessment committee should represent economic sectors, social groups, and ecosystems most at risk from drought. The committee's chairperson should be a member of the task force.

The most effective approach to follow in determining vulnerability to and impacts of drought is to create working groups under the aegis of the risk assessment committee. The responsibility of the committee and working groups is to assess sectors, population groups, and ecosystems most at risk and identify appropriate and reasonable mitigation measures to address these risks. Working groups would be composed of technical specialists and stakeholders representing those areas referred to above. The chair of each working group, as a member of the risk assessment committee, would report directly to the committee.
Following this model, the responsibility of the committee is to direct the activities of each of the working groups and make recommendations to the drought task force on mitigation actions.

The number of working groups will vary considerably between states. Colorado has identified eight impact working groups: municipal water, wildfire protection, agricultural industry, commerce and tourism, wildlife, economic, energy loss, and health. Idaho's drought plan outlines the responsibilities of five subcommittees: water data, public information, agriculture, municipal supplies and water quality, and recreation and tourism. New Mexico uses four sub-groups: agricultural; drinking water, health, and energy; wildlife and wildfire protection; and tourism and economic impact. Nebraska's drought plan identifies two working groups: agriculture, natural resources, wildlife, tourism, and recreation; and municipal water supply, health, and energy.

A methodology for assessing and reducing the risks associated with drought has recently been completed as a result of collaboration between the NDMC and the Western Drought Coordination Council's (WDCC) Mitigation and Response Working Group (Knutson et al., 1998) and is available on the NDMC's website at http://drought.unl.edu/handbook/risk.pdf. The guide focuses on identifying and assigning priorities to drought impacts, determining their underlying causes, and choosing actions to address the underlying causes. This methodology can be employed by each of the working groups. This effort requires an interdisciplinary analysis of impacts and management options and is divided into six tasks:

A. Assemble the team. Select stakeholders, government planners, and others with a working knowledge of drought's effects on primary sectors, regions, and people.

B. Evaluate the effects of past droughts. Identify how drought has affected the region, group, or ecosystem. Consult climatological records to determine the "drought of record," the worst in recorded history, and project what would happen if a similar drought occurred this year or in the near future, considering changes in land use, population growth, and development that have taken place since that drought.

C. Rank impacts. Determine which drought effects are most urgently in need of attention. Various considerations in assigning priority to these effects include cost, area extent, trends over time, public opinion, social equity, and the ability of the affected area to recover.

D. Identify underlying causes. Determine those factors that are causing the highest levels of risk for various sectors, regions, and populations. For example, an unreliable source of water for municipalities in a particular region may explain the impacts that have resulted from recent droughts in that area. To reduce the potential for drought impacts in the future, it is necessary to understand the underlying environmental, economic, and social causes of these impacts. To do this, drought impacts must be identified and the reason for their occurrence determined.

E. Identify ways to reduce risk. Identify actions that can be taken before drought that will reduce risk. In the example above, taking steps to identify new or alternative sources of water (e.g., ground water) could increase resiliency to subsequent episodes of drought.

F. Write a "to do" list. Work with the task force to assign priority to options according to what is likely to be the most feasible, cost-effective, and socially equitable. Implement steps to address these actions through existing government programs or the legislative process. This process has the potential to lead to the identification of effective and appropriate drought risk reduction activities that will reduce long-term drought impacts, rather than ad hoc responses or untested mitigation actions that may not effectively reduce the impact of future droughts.

Step 6: Integrate Science and Policy, Close Institutional Gaps

An essential aspect of the planning process is integrating the science and policy of drought management. The policy maker's understanding of the scientific issues and technical constraints involved in addressing problems associated with drought is often limited. Likewise, scientists generally have a poor understanding of existing policy constraints for responding to the impacts of drought. In many cases, communication and understanding between the science and policy communities must be enhanced if the planning process is to be successful. Integration of science and policy during the planning process will also be useful in setting research priorities and synthesizing current understanding. The drought task force should consider various alternatives to bring these groups together and maintain a strong working relationship.

As research needs and gaps in institutional responsibility become apparent during drought planning, the drought task force should compile a list of those deficiencies and make recommendations on how to remedy them to the governor, relevant state agencies, and the legislature. For example, the monitoring committee may recommend establishing or enhancing a ground water monitoring program. Another recommendation may be to initiate research on the development of a climate or water supply index to help monitor water supplies and trigger specific actions by state government.

Step 7: Publicize the Proposed Plan, Solicit Reaction

If there has been good communication with the public throughout the process of establishing a drought plan, there may already be better-than-normal awareness of drought and drought planning by the time the task force recommends various drought mitigation and response options. Themes to emphasize in writing news releases and organizing informational meetings during and after the drought planning process could include: How the drought plan is expected to relieve impacts of drought. Stories can focus on the human dimensions of drought, such as how it affects a farm family, on its environmental consequences, such as reduced wildlife habitat; and on its economic effects, such as the costs to a particular industry or to the state's overall economy. What it will cost to implement each option, and how it will be funded. What changes people might be asked to make in response to different degrees of drought, such as restricted lawn watering and car washing, or not irrigating certain crops at certain times.

In subsequent years, it may be useful to do "drought plan refresher" news releases at the beginning of the most drought-sensitive season, letting people know whether there is pressure on water supplies or reason to believe that there will be shortfalls later in the season, and reminding them of the plan's existence and history and any associated success stories. It may be useful to refresh people's memories ahead of time on circumstances that would lead to water use restrictions.

During drought, the task force should work with public information professionals to keep the public well informed of the current status of water supplies, whether conditions are approaching "trigger points" that will lead to requests for voluntary or mandatory use restrictions, and how victims of drought can access assistance. All pertinent information should also be available on the state's drought website so that the public can get information directly from the task force without having to rely on mass media.

Step 8: Implement the Plan

Once the task force and any external constituencies have agreed on the plan, the task force and/or its designated representatives should oversee implementation of both the short-term operational aspects of the plan and long-term mitigation measures. Periodic testing, evaluation, and updating of the drought plan will help keep the plan responsive to state needs. An ongoing or operational evaluation keeps track of how societal changes such as new technology, new research, new laws, and changes in political leadership may affect drought risk and the operational aspects of the drought plan. Drought risk may be evaluated quite frequently while the overall drought plan may be evaluated less often. An evaluation under simulated drought conditions (i.e., drought exercise) is recommended before the drought plan is implemented and periodically thereafter. The virtual drought exercise developed in association with a recent national study conducted by the U.S. Army Corps of Engineers (Werick and Whipple, 1994) is one mechanism that has been used to simulate drought conditions and related decisions. It is important to remember that drought planning is a process, not a discrete event.

Long-term mitigation measures, such as implementing policies that require conjunctive use of ground and surface water, may require drafting new legislation and finding funds to support new monitoring and regulation efforts. In any case, it is essential to recognize that reducing long-term vulnerability to drought will require a sustained effort, although it may be a matter of long-term programs undertaken by a variety of agencies.

Step 9: Develop Education Programs

A broad-based education program to raise awareness of short- and long-term water supply issues will help ensure that people know how to respond to drought when it occurs and that drought planning does not lose ground during non-drought years. It would be useful to tailor information to the needs of specific groups

(e.g., elementary and secondary education, small business, industry, homeowners, and utilities). The drought task force or participating agencies should consider developing presentations and educational materials for events such as a water awareness week, community observations of Earth Day, relevant trade shows,
specialized workshops, and other gatherings that focus on natural resource stewardship or management.

Step 10: Post-Drought Evaluation

A post-drought evaluation or audit documents and analyzes the assessment and response actions of government, nongovernmental organizations, and others, and provides for a mechanism to implement recommendations for improving the system. Without post-drought evaluations, it is difficult to learn from past successes and mistakes, because institutional memory fades.

Post-drought evaluations should include an analysis of the climatic and environmental aspects of the drought; its economic and social consequences; the extent to which pre-drought planning was useful in mitigating impacts, in facilitating relief or assistance to stricken areas, and in post-recovery; and any other weaknesses or problems caused or not covered by the plan. Attention must also be directed to situations in which drought-coping mechanisms worked and where societies exhibited resilience; evaluations should not focus only on those situations in which coping mechanisms failed. Evaluations of previous responses to severe drought are also a good planning aid.

To ensure an unbiased appraisal, governments may wish to place the responsibility for evaluating drought and societal response to it in the hands of nongovernmental organizations such as universities and/or specialized research institutes.

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[i] Blaikie et al., 1994

Appendix G

UTAH DIVISION OF WILDLIFE RESOURCES

DROUGHT RESPONSE PLAN FOR WILDLIFE

Approved by the UTAH WILDLIFE BOARD on August 13, 2002

INTRODUCTION

The State of Utah is experiencing an extended drought with only occasional wetter years. Conditions for fish and wildlife have gradually deteriorated over this period throughout much of the state. Already this year range conditions have deteriorated to critical, nearly unprecedented levels. Stream flows and reservoir levels are in fair shape depending on where they occur, and angling appears good in many locations despite drought circumstances. Continuing drought conditions will no doubt worsen in some areas, although outdoor recreation including angling is expected to remain popular and enjoyable in many parts of the state. Southern Utah is experiencing particularly severe conditions, although almost every part of the state is affected to some degree. Conditions are tough, and there will be impacts although hunting and fishing should still provide good enjoyment throughout the year.

The purpose of this response plan is to inform Division personnel and others concerning the drought, its impacts on wildlife, actions needed to cope with drought conditions, key Division policies for dealing with critical issues, and appropriate means for disseminating information. This is necessary to ensure consistency and accuracy in informing the public of drought impacts on wildlife and related recreational opportunities which may interest them.

Our foremost concern is for the welfare of wildlife. We are also concerned about drought impacts on revenue to the Division and our ability to carry out Division programs that benefit wildlife. We want to emphasize the quality of time spent recreating outdoors, regardless of whether a drought is on-going. We should encourage participation in hunting and angling among those who enjoy participating in these sports.

SUMMARY OF DROUGHT IMPACTS ON WILDLIFE

Fisheries

A prolonged drought may cause severe losses of fish in many streams, lakes, and reservoirs. Much of this loss is not preventable, and angling quality may be temporarily reduced. At present, the impacts have not grown to severe levels in most locations and angling opportunities remain very good. Low stream flows and lake levels typically result in increased water temperature and consequent decreased dissolved oxygen content.

Increased biochemical oxygen demand, due to greater organic debris relative to the volume of water present, may further deplete oxygen levels and cause additional fish losses due to suffocation.

Low stream flows in populated or industrialized areas can concentrate pollutants beyond fish tolerance levels and cause further mortality.

Low stream flows and resulting water shortages for crop irrigation usually results in increased efforts to chemically control aquatic vegetation in canals and ditches. Improper use of herbicides can result in extensive fish kills.

Low water levels in lakes resulting from extended drought can jeopardize fish populations in many reservoirs, and especially in small high mountain lakes, by a threat of winter kill.

As water levels diminish in lakes, reservoirs and streams, fish carrying capacity also declines. If levels are significantly reduced, excess fish either move, are caught by anglers, or simply die. Obviously, given those choices, an increased harvest is most desirable, since there is usually little opportunity for movement to better water conditions, and fish may be concentrated and easy to harvest. This fact produces good angling opportunities where conditions are right, and anglers can benefit during early months of the summer.

Given the above impacts of drought on our fisheries, the fisheries outlook for the future hinges on the moisture received between now and winter. Angling after all is fun, and the quality of the experience can be emphasized over the catch rate.

Wildlife

Adverse impacts of drought on terrestrial wildlife can most simply be summarized as depletions of cover, food, and water and the effects of these depletions on productivity and populations.

Impacts on individual species vary, but it is safe to assume that extended severe drought will cause significantly reduced reproductive success and declining populations of most species. This is unavoidable except in areas where wildlife water developments may provide some respite from the drought, although vegetation growth is still affected in those areas.

Greatest impacts of the current drought have been observed with those species found primarily in desert and desert mountain areas where forage and drinking water supplies are limiting, even in normal moisture years. Reduced plant growth and vigor has also been significant on seasonal ranges for migratory species such as mule deer and elk.

A lack of sufficient spring and summer rainfall for several years has had an adverse effect on vegetation growth and resulting range condition and trend over much of the state. Forage supplies for many wildlife species are extremely low, except in some of the higher mountains which naturally receive higher precipitation. Competition for forage between livestock and wildlife is much greater than normal, as forage is reduced. This has intensified agricultural depredation in certain areas.

Big game - Mule deer, elk, pronghorn, and bison herds appear to reflect the impacts of prolonged drought and deteriorating range conditions: i.e., winter kill, reduced production of young, and decreased fawn/calf survival through summer. Pronghorn production has been particularly hard hit for the past three years on many of the state's wildlife management units. Some units have shown almost no recruitment into the population for three years.

Drought impacts are clearly demonstrated in mule deer productivity data for the past several years. For the first time in several years, estimated statewide deer population numbers in 2002 have decreased from about 10,000 animals this past year after previously steady increases since the winter of 1992-93. Most of the decreases have occurred in the southern and eastern deer management units.

Big game animals, especially antelope and deer in dry areas, are also adversely affected by the loss of springs, seeps, and other drinking water sources. A secondary, significant effect can be heavy forage use by animals forced to concentrate around remaining water supplies. These habitat impacts can last many years longer than the drought itself. Concentration of big game animals around water sources also can increase the transmission likelihood of certain diseases (e.g., blue-tongue virus in mule deer).

Drought conditions invariably result in increased depredation of private irrigated croplands. Such damage poses serious problems and economic impacts to both the farmers and the Division.

A most serious concern in big game management in Utah, that is magnified in drought years, is big game/livestock competition for forage on critical big game ranges. Winter ranges are of particular concern as such areas are typically used by livestock in spring, prior to moving to higher summer ranges, and again in fall. During drought years, very little growth occurs on plant species important to big game. Much of the available growth is used by livestock prior to winter when big game descend to the winter range.

This causes extensive wildlife losses, particularly of mule deer, during winters following drought years. This phenomenon has caused significant mortality in deer populations across the state and can be especially devastating if followed by severe winter conditions as occurred in the winter of 1992-93. With continued drought situations, livestock permittees often see their numbers cut substantially which lessens support for maintaining big game numbers on these same ranges.

Upland game - Upland game populations typically fluctuate widely over time. Such fluctuations are primarily a reflection of annual reproductive success. Reproductive success, on a short-term basis, is principally a function of weather conditions, with the most critical time period being late winter and early spring. Weather affects production either through a direct impact on reproductive success or indirectly through forage production. Extreme weather conditions (temperature and precipitation) generally have a detrimental effect on reproduction; however, not all species are influenced in the same way.

Game birds of relatively dry habitats, such as the chukar, greater sage grouse, and Gambel's quail, are very dependent on the production of annual forbs and grasses. They therefore usually respond well to cool, wet spring weather that produces abundant forage. Forest species -- including the ruffed grouse, blue grouse, and wild turkey -- tend to respond to mild spring weather with less rainfall. Those associated with irrigated areas, such as the ring-necked pheasant, California quail, and Hungarian partridge are most affected by breeding season temperature rather than precipitation. Cold April weather is usually detrimental to these species.

Extreme drought conditions which significantly reduce vegetation growth, forage production, and available drinking water will undoubtedly adversely impact all upland game species.

Waterfowl - Drought invariably results in a drying up of many natural wetlands and reduced water levels and decreasing water quality in managed marshes. Extensive drought in waterfowl production areas always results in population declines due to the loss and degradation of nesting and brood-rearing habitat.

Extensively developed wetlands can temper impacts on local waterfowl numbers to the extent that water levels and marsh conditions can be maintained.

Waterfowl habitat not associated with the Great Salt Lake, has been and will continue to be adversely affected by drought in three basic ways: (1) reduced inflows, (2) increased evaporation, and (3) reduced water quality. Impacts will be less in spring-fed marshes than in those dependent upon surface flows.

Because most waterfowl management areas are at the "end-of-the-ditch" we can expect not only reduced flows, but also substantially poorer water quality. The extent to which this will impact waterfowl production and use of the areas will depend on the extent of the drought in any given area.

Another major waterfowl threat that is often linked with poor water quality and reduced flows is avian botulism. This disease can kill literally hundreds of thousands of waterfowl and shorebirds in a few week period and is extremely difficult to control. This disease tends to recur in the same general area when conditions are suitable. Historic hot spots include most wetlands along the eastern shore of the Great Salt Lake and Provo Bay on the Utah Lake system.

Sensitive species - Animals categorized as sensitive species include fish, mammals, amphibians, reptiles, and birds which are typically not harvested. There is great variation among species insofar as habitat requirements are concerned, and consequent diverse responses to drought. Even so, it is safe to conclude that prolonged drought will not benefit any species, even those well adapted to dry conditions. Impacts on food supplies should affect them if nothing else. Smaller mammals and larger predators which depend on smaller mammals, especially those associated with desert/upland areas, will be adversely impacted.

There is particular concern for those species known to be endangered, threatened, or of known sensitive status. Severe drought reflected in greatly reduced stream flows or forage production could set back recovery efforts. Low flows may diminish spawning success of endangered fishes in the Colorado River system.

Natural biotic communities have evolved with an ability to cope with drought. While population levels may fluctuate widely, they can be expected to recover.

The drying of wetlands, riparian, grassland, and rangeland habitat reduces nesting areas and decreases insect food bases, which diminish avian productivity. Wetland and riparian habitats are particularly rich in avian diversity and are affected the greatest by drought conditions.

In addition to drought effects described above under **Fisheries**, reproduction and recruitment of sensitive species fishes is adversely affected by low stream flows and reduced water quality associated with their spawning and rearing periods. Low flows have seriously impacted spawning of the endangered June sucker during past dry years.

DROUGHT MITIGATION ALTERNATIVES

Fisheries

The current drought has already adversely affected stream flows, reservoir storage, water temperature, and water quality in many areas. As it continues we can expect further declines and possible fish losses. Nothing can be done to restore lost stream flows. Despite the effects of drought, fishing remains good in many areas.

The Aquatics Section has already adjusted hatchery production and fish distribution schedules to compensate for drought conditions. Regional fisheries managers have been given full authority to modify stocking quotas and schedules within constraints imposed by drought conditions.

Despite the drought, there are many opportunities for good fishing. It is extremely important that we apprise the public of these opportunities now, and throughout the summer and fall. This will require a joint effort by Aquatics, Conservation Outreach, and Law Enforcement to monitor water conditions and fishing success and inform the public accordingly.

We must closely monitor conservation pool levels and prescribed minimum stream flows to assure compliance with contract or permit conditions and to ensure the Division's water rights are protected.

Hatchery personnel and regional fisheries managers must evaluate fish stocking needs in light of the current drought in order to program hatchery production schedules.

Division personnel must be prepared to respond to fish kills when assigned. Such losses can be expected as a result of low water levels, excessive diversions, low oxygen levels, and chemical treatments to control aquatic vegetation. Each incident must be investigated by appropriate personnel, making certain to notify appropriate contact people in the Department of Environmental Quality as is typically done in these matters.

We must anticipate losses in perennial problem areas and initiate efforts to avoid losses to the extent possible. Regions must take the lead in this effort. Cooperative efforts with irrigation companies may prevent or minimize losses.

Wildlife

Reduced production and subsequent wildlife population declines have already somewhat lessened grazing pressures on rangelands to some degree. This is expected to continue through this year, and in some ways matches the cuts which livestock producers have been forced to take. The Wildlife Board has established harvest regulations for 2002 that have taken into consideration potential problems with continued drought, and harvest numbers reflect these considerations. It is essential that wildlife managers further monitor range conditions to ensure an appropriate future balance between herd size and carrying capacity. This must be done in concert with the federal land management agencies who control the dominant share of habitat.

Water developments installed for wildlife must be maintained in good working order. Consideration should be given to the feasibility of hauling water in critical situations. Land management agencies should be encouraged to ensure proper maintenance of water developments benefiting wildlife.

It is expected that depredation problems will escalate and every effort -- within legal, funding, and work force constraints -- must be made to assist farmers and ranchers in minimizing wildlife impacts on crop production. In areas where big game herds are substantially below management objective, killing of animals that move into agricultural lands during drought should be minimized where possible.

The new tools we have to deal with big game depredation on private cultivated land will help alleviate some problems. These tools were not available in 1993, and include the changes in the Utah Code for irrigation equipment and fence damage, antlerless mitigation permits for landowners, the development of a statewide depredation account, and the hiring of many full-time/seasonal personnel by the Division to deal with landowners' needs and their depredation problems in the regions.

Drought usually increases nuisance beaver complaints in canals and ditches. A diligent effort will be required to control these problems at a time when water is in short supply.

Dry, unproductive rangelands may cause unusual dispersal of young bears. Increased human/bear conflicts can be expected and must be handled promptly and within policy guidelines.

In the final analysis, little can be done to significantly alter the impact of extreme drought on wildlife populations. We must work with the public in an informational mode to provide accurate information on drought and its effects on wildlife.

Management efforts should focus on diminishing or avoiding human-caused disturbances that further stress populations whose status is already tenuous.

Waterfowl management area superintendents must closely monitor inflows and adjust water levels in individual units in a way that maximizes habitat quantity and quality. They will also need to closely monitor waterfowl populations for signs of botulism and implement remedial actions required to minimize losses and diminish public concerns.

GUIDELINES FOR DISSEMINATION OF INFORMATION

Concerning Drought Impacts on Fish and Wildlife

Information should be provided to the media and the public so that it becomes clear the Division is aware of the many drought-related problems, and that steps have been and will continue to be taken to cope to the extent feasible.

The public should understand that the Division has considered drought impacts in the establishment of harvest regulations, and that prescribed harvests are within harvestable surpluses of game species.

News releases should stress that hunting and fishing will not be detrimental to populations, and that a reasonable harvest will minimize natural mortality next winter. This is especially true of big game populations that must be kept within management objectives. An adequate harvest not only will tend to minimize potential winter loss, but at the same time will relieve pressure on short forage supplies and help conserve range conditions for the future.

We must be candid in explaining potentials for mitigating drought impacts on widespread populations of fish and wildlife. Drought conditions are natural, wildlife species are generally adapted to them, but drought is often unpleasant. We must be sensitive to deep-seated public concern for the welfare of wildlife during drought, and take the appropriate actions where we can.

Concerning Fishing

Drought conditions dictate a need to increase our conservation outreach efforts over a "normal" year. We must make an <u>extra</u> effort to inform the public of promising fishing opportunities which in fact can be quite good during drought conditions, at least in certain areas. Aquatics personnel, Habitat and Wildlife staff, and conservation officers must take the initiative to provide our Conservation Outreach staff with needed information and guidance on drought matters. We need to help the public identify the waters which are providing good angling during different times through the year, and Conservation Outreach staff need detailed up-to-the-minute reports they can use in various information releases which should help the public during this drought period.

The following key points should be considered in the preparation of news releases:

* Be positive and upbeat about fishing opportunities.
* Identify current hot spots that can sustain pressure, and the increased fishing opportunities in reservoirs and lakes subject to fishing proclamation changes.
* Make timely news releases.
* Emphasize opportunities on the larger reservoirs and in fisheries below reservoirs.
* Stress that even with the drought, fishing is one of the greatest outdoor recreational opportunities available, and at the best price.
* Encourage use of relatively unfished areas that provide good opportunity, such as the high mountain lakes of the Uintas and Starvation Reservoir for walleye.
* Place greater emphasis on the growing smallmouth bass fisheries in Rockport, Flaming Gorge, and Lake Powell.
* Identify regional variation in drought conditions and fishing opportunities.
* Be honest, absolutely honest as at all times, but be prudent. It is not dishonest to state that fishing is always good, but sometimes it is better than at other times. Advise the public in the way you would want to be advised if the roles were reversed.
* In communicating with the mass media, be sure your information is accurate. If you do not know, tell them that; seek to find the answers the press needs.

Concerning Hunting

As with fishing, a concerted Conservation Outreach effort will be needed to inform the public of hunting opportunities. Wildlife Managers must work closely with Conservation Outreach to provide needed information.

It is important that we emphasize that a harvestable surplus exists in hunted populations, even during drought years. It is important that hunting be used in critical situations where wildlife populations can potentially exceed a drought reduced carrying capacity.

The following key points should be considered in the preparation of news releases during the continuing drought conditions:

* If dry conditions persist, a major effort will be needed to warn of fire danger and possible local closures as fire prevention measures.
* Stress the importance of annual harvest of big game in maintaining a proper balance between herd size and available forage. Habitat damage is long term.
* Stress that antlerless permits authorized for big game species are intended to ensure keeping herd size in balance with available forage.
* Emphasize species which should provide good hunting.
* Avoid predictions of hunter success which becomes very hard to predict during times of drought.

DROUGHT-RELATED POLICIES

Protection of Fish Conservation Pools

Drought-caused declines in stream flows and reservoir water levels inevitably result in local government requests for using water reserved in fish conservation pools for culinary and irrigation use. The Division is obligated to protect conservation ("C") pools purchased for fish using sportsmen's money - after all, drought conditions are the only time when conservation pools are needed! Nonetheless, we must also be sensitive to critical human needs.

Regional supervisors will take the lead in negotiating "C" pool protection and possible diversion to satisfy critical human needs, if, when, and where it becomes necessary. It must be understood that the Division is willing to work cooperatively with local government in seeking solutions to their problems, but we will only surrender water in fish conservation pools **as a last resort** in meeting critical needs. The following guidelines apply to such negotiations:

1. Fish conservation pool water will be relinquished only for critical culinary use, **not** for irrigation or industrial purposes.

2. Conservation pool water will not be provided in lieu of strict water conservation measures being implemented by local government.

3. Any use of conservation pools for culinary purposes

will be kept to the minimum required to meet an existing crisis. As much water as possible should be retained in a "C" pool to protect the fishery.

4. The minimum conditions for relinquishing "C" pool water will be that the Division receive first priority replacement from subsequent increased stream flows, at no cost to the Division.

   Compensation at fair market value for water provided or for fishery replacement costs may be required in some situations. Such decisions will be made by the Director on a case-by-case basis, in consultation with the Regional Supervisor.

5. A written agreement between the Division Director and local officials must be executed before relinquishing any "C" pool water. Such agreement must specify the quantity of water to be used, the timing of use, and compensation required.

   Failure to adequately protect conservation pools purchased with Federal Aid funds will jeopardize future Federal Aid appropriations, and as such the Director will secure approval from Federal Aid prior to any such agreement being made.

Following is a list of conservation pools and stabilized lakes owned by the Division. Regional Supervisors and Aquatics Managers must review this list and identify potential areas of conflict. If a local demand for water is anticipated, supervisors should consider initiating contacts with community/water company officials to advise them of actions required before submitting requests for "C" pool water: e.g., implementation of strict water conservation measures. Without having first exhibited strict water conservation measures being put in place and enforced, no water will be relinquished.

Occasionally, a demand for "C" pool water will coincide with Division goals to treat or repair reservoirs. In such instances, Regional supervisors are granted the latitude to negotiate the best interest of the Division, aside from the above guidelines.

Conservation Pools/Stabilized Lakes

The Division of Wildlife Resources has in the past and is presently pursuing opportunities to enhance fishing recreation on Utah's lakes and reservoirs. In an effort to preserve aquatic habitat, "Conservation Pools" and "Stabilized Lakes" are acquired to provide the environment needed to sustain fish populations on a year-round basis.

The term conservation pool refers to a given volume of water that is maintained in a reservoir basin. In most cases, conservation pools are acquired from irrigation companies to provide needed fish habitat. Generally speaking, this amounts to the minimum water level to which the company may release water from the reservoir.

Stabilized lakes on the other hand are reservoirs that are maintained at a given water level to provide recreational fishing. These reservoirs, or lakes, are kept at a constant volume and water level is fluctuated only when it becomes necessary to protect fish populations or satisfy dam safety requirements.

Conservation pools and stabilized lakes are extremely important in the management of Utah's fisheries program. The following is a list of conservation pools and stabilized lakes that have been acquired by the Division of Wildlife Resources in an effort to preserve aquatic habitat.

CONSERVATION POOLS

Name of Water	Year Acquired	Acre Feet	County	Region
Yankee Meadows Reservoir	1940	300	Iron	Southern
Upper Enterprise Reservoir	1942	200	Washington	Southern
Scofield Reservoir	1944	8,000	Carbon	Southeast
Navajo Lake	1958	3,000	Kane	Southern
Red Creek Reservoir	1959	128	Duchesne	Northeast
Lower Bown Reservoir	1959	725	Garfield	Southern
East Park Reservoir (F-13-D)	1960	1,300	Uintah	Northeast
Porcupine Reservoir	1960	1,500	Cache	Northern
Blanding Reservoir No. 3	1961	64	San Juan	Southeast
Woodruff Narrows Res. (F-16-D)	1962	4,000	Wyoming	Northern
Tibble Fork Reservoir	1963	166	Utah	Central
Big Sandwash Reservoir (F-19-L)	1965	1,200	Duchesne	Northeast
Blanding Res. No.4 (F-4-D-1, *APW)	1965	219	San Juan	Southeast
Minersville Res. (F-20-L), Rocky Ford	1965	2,000	Beaver	Southern
Johnson Valley Reservoir (F-18-D)	1965	2,500	Sevier	Southern
Pelican Lake (F-21-L)	1966	4,500	Uintah	Southeast
Whitney Reservoir	1967	500	Summit	Northern
Upper Woodruff Res. (F-23-L)	1968	450	Rich	Northern
(Additional acquired) (F-57-L4)	1989	249		
Birch Creek Reservoir (F-23-L)	1968	400	Rich	Northern
Mill Site Reservoir (F-25-L)	1968	2,000	Emery	Southeast

Gunlock Reservoir (F-27-D)	1970	1,014	Washington	Southern
Silver Lake Flat Reservoir	1971	100	Utah	Central
Newcastle Reservoir	1974	500	Iron	Southern
Brough Reservoir (F-33-L)	1975	1,145	Uintah	Northeast
Kents Lake Reservoir	1977	300	Beaver	Southern
Paragonah Reservoir (F-36-D)	1980	350	Iron	Southern
Long Park Reservoir (F-35-D)	1980	3,000	Daggett	Northeast
Oak Creek Reservoir (F-37-D)	1982	370	Garfield	Southern
Cottonwood Reservoir	1983	700	Uintah	Northeast
Woods Pond (F-57-L-6)	1989	6	Iron	Southern
Upper Kents Lake (F-57-L-13)	1992	80	Beaver	Southern
Sand Hollow (F-27-D)##	2002	1,086	Washington	Southern

*APW (Applied Public Works)
From July 2002 until February 15, 2003, some or all of this conservation pool may be retained in Kolob Reservoir where valuable fisheries exist, and warrant protection

STABILIZED LAKES

Name of Water	Year Acquired	Surface Acres	County	Region
Burraston Ponds (3)	1901	17.3	Juab	Central
Gooseberry Pond	1938	25.0	Sanpete	Southeast
Duck Creek Springs	1939	7.5	Kane	Southern
Aspen-Mirror Lake	1939	3.0	Kane	Southern
Pine Lake (F-31-D)	1947	80.0	Garfield	Southern
Monticello Lake (F-6-D)	1954	3.5	San Juan	Southeast
Browne Lake (F-10-D)	1958	54.0	Daggett	Northeast
Anderson Meadow Lake (F-11-D)	1958	8.7	Beaver	Southern
Sheep Creek Lake (F-12-D)	1959	80.0	Daggett	Northeast
Barker Reservoir (F-34-D)	1960	12.0	Garfield	Southern
Lower Barker Reservoir	1960	5.0	Garfield	Southern
Long Willow Bottom Res. (F-34-D)	1960	5.0	Garfield	Southern
Round Willow Bottom Res. (F-34-D)	1960	9.0	Garfield	Southern
Joe Lay Reservoir (F-34-D)	1960	4.0	Garfield	Southern
Mill Hollow Lake (F-15-D)	1962	17.1	Wasatch	Central
LeBaron Lake (F-2-D-1, *APW)	1965	23.0	Beaver	Southern
Crouse Reservoir	1966	115.0	Uintah	Northeast
Foy Lake	1966	4.9	San Juan	Southeast
Ferron Reservoir (566 **SWP)	1974	65.0	Sanpete	Southeast
Bullock Reservoir	1977	90.0	Uintah	Northeast
Duck Fork Reservoir (566 **SWP)	1977	42.0	Sanpete	Southeast
Willow Lake (566 **SWP)	1977	25.0	Sanpete	Southeast
Wrigley Springs Reservoir (F-25-L)	1980	12.7	Sanpete	Southeast
Calder Reservoir (F-40-L)	1980	100.0	Uintah	Northeast

Matt Warner Reservoir (F-40-L)	1980	356.0	Uintah	Northeast
Manning Meadow Res. (F-57-L1)	1988	55.0	Piute	Southern
Barney Lake (F-57-L1)	1988	19.0	Piute	Southern
Deep Lake (F-57-L2)	1988	5.0	Sanpete	Central
Shingle Mill Lake (F-57-L2)	1988	2.0	Sanpete	Central
Daggett Lake	1989	44.0	Daggett	Northeast
Jesson Lake	1989	22.0	Daggett	Northeast
Tamarack Lake	1989	64.0	Daggett	Northeast
Wellsville Reservoir (F-57-L2)	1989	6.0	Cache	Northern
Pacer Lake (F-57-L8)	1996	33.0	Garfield	Southern
Spirit Lake	2000	42.8	Daggett	Northeast
Little Montes Cr. Res. (Ottosen Res.)	2000	16.3	Uintah	Northeast
Gates Lake	2001	5.0	Sevier	Southern
Lake Canyon Lake	2002	25.5	Duchesne	Northeast

*APW (Applied Public Works)
**SWP (Small Watershed Project)

Protection of Prescribed Instream Flows and Flow Rights

Historically, instream flows were not recognized as a beneficial use of water under Utah law. Of course that has changed to permit both the Division of Wildlife Resources and the Division of Parks and Recreation to hold instream flow rights. Several have been established, and they are important. However, even before the instream flow rights, through the years a number of instream flow requirements were established on various waters throughout the state, as stipulated by operating agreements associated with federally-funded water projects. Other flows were derived from hydroelectric licensing requirements or protection of endangered species. In time of drought, the pressure to reduce or eliminate the required instream flows mounts. In almost all cases, the instream flow required is already at the minimum level needed to protect the existing fishery. We should therefore resist efforts to reduce these flows. In most cases the required flows are mandated by federal regulation and the Division therefore has only partial responsibility for making such decisions.

Regional supervisors will take the lead in negotiating any modification to instream flows to satisfy critical human need. It must be understood that the Division is willing to work cooperatively with local government in seeking solutions to their problems, but we will allow reductions in stream flow only **as a last resort** in meeting critical human needs. The following guidelines apply to such negotiations:

1. Instream flow reductions will be agreed to only for critical culinary use, **not** for irrigation or industrial purposes.

2. Instream flow reductions will not be agreed to in lieu of strict water conservation measures being implemented by local government.

3. Any reduction of instream flow will be kept to the minimum needed to meet an existing crisis.

4. Compensation for the instream flow reduction shall be subsequent increases in instream flow during other critical periods, pending approval by the Division Director. In-kind, in-place compensation is preferred, but other kinds may be considered. The Director will make such decisions on a case-by-case basis.

5. Any reductions in instream flow shall be time-limited to 30 days maximum duration, and require written agreement specifying amounts and durations. Involved parties shall reconvene after 30 days to reassess conditions. Agreements may be revoked, modified, or extended at that time.

Fish Salvage

Drought conditions this year will be severe in most parts of the state which will lead to dewatering of streams and lakes. This may cause stranding and/or concentrations of fish. The Division will no longer attempt to salvage fish from one water and move them to another water. This activity is not cost effective, and risk of moving diseases is just too great. This is particularly true since the discovery of whirling disease in the state.

Regional aquatic managers, conservation officers and other Division personnel should carefully monitor areas where fish are likely to become stranded. These sites need to be publicized and anglers encouraged to take a legal limit. In cases where the fish cannot be utilized by maintaining standard regulations, consideration will be given to liberalizing the bag limit. It will be very important for the field personnel to act quickly if these types of situations develop. We can usually amend the proclamation within a 24-hour period if an emergency situation develops.

For further information contact: Bill James, Habitat Section Chief, @ 801.538.4752 OR Bill Bradwisch, Aquatic Habitat

Coordinator, @ 801.538.4866. See the Division's website at http://www.wildlife.utah.gov and thank you for helping to conserve Utah's wildlife and natural diversity.

Drought to impact wildlife

July 31, 2002

by Walt Donaldson NER DWR Supervisor

The Northeastern Region (NER) is in the fourth year of a chronic drought. This year, 2002, is considered by hydrologists to be one of the worst droughts on record for the Uintah Basin. As a general rule, all ranges (particularly lower elevations) have exhibited little or no vegetative growth. The winter snowpack and subsequent precipitation has been marginal or nonexistent, creating lower than normal spring flows and maximum use of reservoir water storage. Prolonged drought, along with limited water supply and low vegetative/soil moisture, creates ideal conditions for large fire events. The following is a brief summary of drought related impacts affecting wildlife and fisheries in the NER.

Pronghorn: The drought has had a serious impact on pronghorn due to depleted water sources in arid units, loss of succulent forbs for lactation by does, and no forage production on their winter ranges. Water has been hauled to guzzlers on the Myton and East Bench units, but not on the more northern and eastern units (i.e., North Slope, Daggett and Three Corners, South Slope--Vernal, Diamond Mtn, and Bonanza). The long term impacts to pronghorn are now being documented in terms of population reduction. For example, aerial counts of animals on the Myton Unit by fixed wing in 1998 were about 1,400 pronghorn; the same type of count for this unit in 2002 was about 350 pronghorn...or a relative herd reduction of about 75 percent in only four years. Fawn production is significantly down on all units within NER, and has been declining during the last four years.

Deer: The drought has impacted deer winter ranges as browse production region wide has been minimal or nonexistent since early spring. Marginal production of grasses and stem growth of browse has occurred in the Uinta Mountains on summer ranges. But no production has occurred with grasses or browse on summer ranges in the more desert herd units (i.e., Anthro, Book Cliffs). Browse species (mainly sage and four-wing) this summer have desiccated and are showing leaf loss, a protective mechanism used by browse plants during extreme drought periods. Livestock trespass or overgrazing on winter units in portions of the north Book Cliffs unit, Vernal sub-unit and Avintaquin sub-unit have adversely affected the browse. All deer herd units in NER indicated lower fawn production during the 2002 Spring classification. Also, we are now receiving reports that fawns are dying this summer on the Vernal and Diamond Mtn sub-units due to either malnutrition, desiccation or abandonment.

Elk: Range conditions are identical to that described for deer. Due to lack of grass production this spring, it is expected that elk will forage on browse intended for deer, creating higher levels of plant stress this coming winter. Dual species foraging on browse will occur within overlapping winter ranges used by deer and elk, and will cause negative impacts on browse on the desert units south of US Highway 40 on the Book Cliffs and Anthro units, and on the Daggett and Three Corners sub-unit in Browns Park. Some calf production is anticipated, but we won't be able to document any herd population shifts until after the aerial census work scheduled this coming winter.

Moose/Bighorn Sheep: Water availability for these species appears sufficient at this time, as these animals associate themselves to large bodies of water (i.e., moose in the Uintah Mountains and bighorn sheep along the Flaming Gorge/Green River corridor). However, forage production this year is dismal, as it was for the aforementioned big game species. Lower calf/lamb production is anticipated this year for both species.

Bear/Cougar: Bear problems are escalating rapidly in the Uintah Basin due to lack of grass and mast crop production this year. Body condition for bears is poor. NER personnel have documented bear/human interactions since July 1 at the following locations: Camelot Resort on the Strawberry River, and USFS campgrounds at Rock Creek, Yellowstone/Swift Creek, Uinta River, and Lodgepole (U.S. Highway 191 near Flaming Gorge). To date, two bears have been trapped and killed (Strawberry River and Yellowstone). Formal contacts have already been made with Camelot Resort and Ashley National Forest in terms of better garbage or food management. Based on the Book Cliffs bear study, we anticipate very little cub production for 2003. A juvenile cougar was killed by a Tabiona, Utah resident in June, 2002 on the porch of his house. It was in an emaciated, starving condition.

Upland Game/Waterfowl: Both cover and food crops normally provided by the agricultural community in the Uintah Basin will not occur this year. With the exception of irrigation water from Starvation Reservoir, all other irrigation areas will not produce either hay or field grain. Therefore, cover and food grains will be limited for both upland game species and resident/migrating waterfowl. Production of young is predicted to be reduced due to the drought.

Fisheries (reservoirs/lakes): Most of the High Uinta lakes associated with inflowing water are stable and should over-winter trout populations. However, high cirque lakes with limited inflow are expected to have either partial or total winterkill of trout. All reservoirs have or are depleting their water storage. Flaming Gorge, Starvation and Red Fleet reservoirs have not reached minimal storage pool, but are losing their storage of water at a rapid rate. Steinaker, Upper Stillwater, East Park, Oaks Park, Brown's Draw, Paradise, Sand Wash, Moon Lake and Pelican Lake are near or at conservation pool or dead storage. The Diamond Mtn lakes had no inflow of water during spring run off. Crouse Reservoir suffered a winterkill. Matt Warner Reservoir could suffer some fish loss this winter, as it will be used to keep Calder Reservoir alive if the need arises. Cottonwood Reservoir will be drawn down into the conservation pool this Fall in order for some construction work to occur on the outlet works. The irrigation company is working with NER to replace the conservation pool later in the Fall season to avoid winterkill of the bass/tiger muskie fishery. Pelican Lake is at conservation pool; and if no winter flows are provided to this lake for storage as in the past, expect a severe loss of bluegill during ice-on. It should be noted that despite the low storage levels in our reservoirs, many of them are still providing good to excellent fishing.

Fisheries (streams): All streams from the Uinta Mountains are showing lower than normal flows, but impacts to fish populations have not as yet occurred. However, there are no flows below stream diversions throughout the Uintah Basin. The Green River below Flaming Gorge dam is at a minimum flow of 800 cfs, and expected to remain constant through the rest of the year. Streams originating from the Tavaputs Plateau in the southern part of NER are showing some of the lowest flows in years. Examples include Willow Creek (Book Cliffs) and Timber Canyon (Avintaquin). Fish losses are expected in these small plateau streams as spring sources dry up later this summer and fall. Minimal flow releases this spring from Flaming Gorge and low flows on the Yampa River did not flood any of the backwaters or side channels in the middle Green River. Limited reproduction and growth of razorback suckers and Colorado pike minnow are expected to cause a weak year class for these species in 2002. Surprisingly sampling on the river has been very difficult due to clear water associated with very low sediment transport.

Fire

The Uintah Basin has experienced two large fire events during this month. In the long term, both fires will be beneficial to wildlife; as much of the burned areas were either decadent Douglas fir stands (Roadless Area) or pinion/juniper seral stage vegetation (Dutch John). The Mustang fire occurred near Dutch John, Utah and burned just over 20,000 acres (map/Dutch John Draw photo) and is contained.

This fire did close down fishing for a week at facilities near Flaming Gorge dam and on the Green River from the dam to Little Hole. NER personnel are working with the USFS/BLM rehabilitation team to reseed the critical range and watershed areas this fall. This assistance on the rehabilitation is to avoid cheat grass regeneration, develop grass/browse forage for big game (particularly bighorn sheep), and to minimize soil erosion/transport into the Green River (Section A). Reseed funding is provided by DWR's Habitat Council.

The Rattle Complex fire is located along the west Book Cliffs divide and in the Roadless Area. It is still burning, having consumed over 90,000 acres; and is currently 40 percent contained (map). To date, 50 percent or more of the Roadless Area has been burned. NER personnel are working with the BLM/SITLA rehabilitation team to reseed parts of the burned area, and to coordinate with SITLA on restoring the Roadless Area to its former "no unauthorized motor vehicle" status. Replacement of fences, reinstallation of signs, and elimination of fire line roads is part of the work needing to be addressed. Due to the massive extent of this fire, consideration must be given as to what should be done with big game hunting permit holders for the Book Cliffs Roadless Area in both 2002 and 2003. Many deer and elk have temporarily emigrated from the Roadless Area to avoid the burn and to find a source of forage.

Recommendations

— Work with the BLM and USFS to maintain or repair existing guzzlers for big game. This recommendation may be directed by the Board to the State BLM Director and the Regional USFS Supervisor for Utah.

— As funding permits, haul water to those guzzlers that will best be utilized by pronghorn during the rest of the summer and early fall.

— Increase antlerless deer and elk permits for this fall's hunting season as recommended by NER Wildlife Biologists.

— Regarding the Roadless Area hunting permits, consider refunding the permits for this and next year, and then reissue the permits in 2004. Or give individuals the option of turning their permits back in, but retaining their bonus points for future draw opportunities.

— Continue to make nuisance bear/cougar calls a priority. Work with private resort operators and federal agencies in charge of public campground to improve garbage management, proper food containment and public compliance.

— Monitor all DWR conservation pools in reservoirs to ensure compliance. Where reconstruction of outlet structures are necessary (i.e., Cottonwood Reservoir), coordinate with Ouray Park Irrigation Company to replenish the water depletion as a priority before going into the winter months.

— Coordinate with rehabilitation teams on the Mustang and Rattle Complex fires to ensure proper reseeding for watershed and big game forage purposes. Also work with SITLA to continue the compliance associated with "no unauthorized motor vehicles" in the Roadless Area of the Book Cliffs. This effort includes sign replacement, fence repair, and reclamation of fire line roads.

Back to Front